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Performance comparison of hydrological model structures during low flows

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Low flows are still poorly reproduced by common hydrological models since they are traditionally designed to meet peak flow situations best possible. As low flow becomes increasingly important to several target areas there is a need to improve available models.
We present a study that assesses the impact of model structure on low flow simulations. This is done using the Framework for Understanding Structural Errors (FUSE), which identifies the set of (subjective) decisions made when building a hydrological model, and provides multiple options for each modeling decision. 79 models were built using the FUSE framework, and applied to simulate stream flows in the Narsjø catchment in Norway (119 km^2). To allow comparison all new models were calibrated using an automatic optimization method. Low flow and recession analysis of the new models enables us to evaluate model performance focusing on different aspects by using various objective functions. Additionally, model structures responsible for poor performance, and hence unsuitable, can be detected. We focused on elucidating model performance during summer (August - October) and winter low flows which evolve from entirely different hydrological processes in the Narsjø catchment. Summer low flows develop out of a lack of precipitation while winter low flows are due to water storage in ice and snow. The results showed that simulations of summer low flows were throughout poorer than simulations of winter low flows when evaluating with an objective function focusing on low flows; here, the model structure influencing winter low flow simulations is the lower layer architecture. Different model structures were found to influence model performance during the summer season. The choice of other objective functions has the potential to affect such an evaluation. These findings call for the use of different model structures tailored to particular needs.