EGU2020-205, updated on 04 Aug 2021
https://doi.org/10.5194/egusphere-egu2020-205
EGU General Assembly 2020

Model adequacy tests for improving predictions in ungauged basins

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Flow prediction in ungauged catchments is a major unresolved challenge in scientific and engineering hydrology. Meeting this challenge is made difficult by the uncertainty in the "regionalization" model used to transpose hydrological data (e.g., flow indices) from gauged to ungauged basins, and by the uncertainty in the hydrological model used to predict streamflow in the ungauged basin. This study combines recent advances in flow index selection, regionalization via machine learning methods, and a Bayesian inference framework. In addition, it proposes two new statistical metrics, "DistanceTest" and "InfoTest", to assess the adequacy of a model before estimating its parameters. "DistanceTest" quantifies whether a model (hydrological or regionalization) is likely to reproduce the available hydrological information in a catchment. "InfoTest" is based on Bayes Factors and quantifies the information added by a model (hydrological or regionalization) over prior knowledge about the available hydrological information in a catchment). The proposed adequacy tests can be seen as a prerequisite for a model (hydrological or regionalization) being considered capable of providing meaningful and high quality flow time series predictions in ungauged catchments. If a model is found inadequate a priori and rejected, the modeler is spared the effort in estimating the model parameters, which can be a substantial saving.

The proposed regionalization approach is applied to 92 northern Spain catchments, with 16 catchments treated as ungauged. It is found that (1) a small number of PCs capture approximately 87% of variability in the flow indices, and (2) adequacy tests with respect to regionalized information are indicative of (but do not guarantee) the ability of a hydrological model to predict flow time series. The adequacy tests identify the regionalization of flow index PCs as adequate in 12 of 16 catchments but the hydrological model as adequate in only 1 of 16 catchments. In addition, the case study results suggest that the hydrological model is the main source of uncertainty in comparison to the regionalization model, and hence should receive the main priority in subsequent work at the case study catchments.