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Are Machine Learning methods robust enough for hydrological modeling under changing conditions?

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The advancement of big data and increased computational power have contributed to an increased use of Machine Learning (ML) approaches in hydrological modelling. These approaches are powerful tools for modeling non-linear systems. However, the applicability of ML in non-stationary conditions needs to be studied further. As climate change will change hydrological patterns, testing ML approaches for non-stationary conditions is essential. Here, we used the Differential Split-Sample Test (DSST) to test the climate transposability of ML approaches (e.g., calibrating in a wet period and validating in a dry one, and vice-versa). We applied five ML approaches using daily precipitation and temperature as input for the prediction of the daily discharge in six snow-dominated Swiss catchments. Lower and upper benchmarks were used to evaluate performances through a relative performance measure. The lower benchmark is the average of the bucket-type HBV model runs from 1000 random parameter sets. The upper benchmark is the automatically calibrated HBV model. In comparison with the stationary condition, the models performed slightly poorer in the non-stationary condition. The performance of simple ML approaches was poor for non-stationary conditions with an underestimation of peak flows, as well as a poor representation of the snow-melting period. On the other hand, a more complex ML approach (deep learning), the Long Short -Term Memory (LSTM), showed a good performance when compared with the lower and upper benchmarks. This might be explained by the fact that the so-called memory cell allowed to simulate the storage effects.