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Do good simulation performances at gauged stations mean good semi-distributed hydrological model? An analysis for prediction in ungauged basins.

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One main advantage of semi-distributed models, compared to simpler lumped models, is their capacity to provide streamflow simulations on multiple points inside a catchment. Gauged stations inside a catchment are a source of information that the semi-distributed model can take into account in order to provide spatially consistent simulations. Intuitively, one could think that those measurements, if topologically well integrated into a semi-distributed hydrological model, should facilitate the calibration of a semi-distributed model and its streamflow simulations at ungauged locations. In order to test this hypothesis, we have implemented the sequential calibration strategy proposed by Lerat et al. (2012), which was developed to improve the performance of hydrologic simulations at river sections inside a catchment. We tested the hypothesis that, under this calibration strategy, a semi-distributed model performs better than a lumped model in terms of prediction in ungauged catchments. The results showed that the performance of a semi-distributed model can, in fact, be much lower than the performance of a lumped model, especially for small ungauged catchments. Following these findings, we proposed a new calibration strategy for semi-distributed models, which is supported by a regionalisation strategy based on spatial proximity. In regionalisation studies, spatial proximity is known to provide better performance than physical similarity, which is, however, more commonly used in the calibration of semi-distributed models. In our study, a multi-objective function is defined in order to maximize performance and minimize unnecessary divergence from a regionalised parameter set. The new strategy is applied to a large database of over 1270 catchments in France, with drainage areas between 15 km^2 and 110,000 km^2. The semi-distributed rainfall-runoff model is a daily simulation model with five free parameters for each sub-catchment, in addition to a streamflow velocity parameter for flow routing (de Lavenne et al., 2016). The results show that the additional constraint added in the calibration procedure brings substantial improvements to the quality of the hydrologic simulations, especially in the small ungauged catchments. This opens perspectives for more robust and spatially consistent streamflow simulations for large-scale hydrologic studies.

References

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