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Hydrological ensembles to improve monthly flow predictions in the Magdalena – Cauca macrobasin, Colombia

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Multi-model and multi-analysis procedures have shown that predictions made using ensembles that take into account different model structures and different meteorological forcing datasets are more skillful and reliable. To understand more about forcing data, model structures and interactions between them, the Bayesian Model Averaging (BMA) has been applied in hydrology mainly to forecast combinations among several hydrological models. In this regard, BMA was implemented in the Magdalena Cauca Macro Basin (MCMB) in Colombia (257,000 km2) using different ensemble structures (e.g., number and type of members) determining the weight of each member in each ensemble and quantifying their predictive ability using the Kling-Gupta Efficiency (KGE) deterministic metric.

The BMA was applied in the MCMB on a monthly timescale, obtaining the weights per member in ensembles developed to represent observed discharges in 88 streamflow gauges selected in the MCMB during the period 1981-2011. For each gauge station the best ensembles were selected from a set of possible combinations (e.g., 65,519 cases per gauge station) that comprised the hydrological and land surface models: VIC, wflow-hbv, MESH and DWB, forced with three different meteorological datasets: quasi-observed, WFDEI and MSWEP; the EartH_2Observe Tier-1 ensemble; and a set of global hydrological models (LISFLOOD, WaterGAP3 and HTESSEL) forced with MSWEP. Using BMA, the Gaussian mixture model was constructed by weighing the posterior distribution of individual hydrological models in the transformed space. The posterior probability measuring samples belonging to each specific hydrological model were treated as the weights.

The results of the best ensembles (TBE) for the 88 streamflow gauges selected in the MCMB showed increases in the evaluated performance through KGE, in comparison with the best individual models (TBM). The 46.59 % of the stations reported KGE values during calibration higher than 0.81 using TBE, while in the case of TBM the percentage was lower (23.86 %). In the [0.61-0.80] range of the KGE, the results with the TBE reported a percentage of 29.22 % in comparison with a 42.05 % of TBM; similar results were also obtained in the ranges [0.41-0.60] and [0.21-0.40] of the KGE.

A high diversity in the members of the ensembles was observed, yet for streamflow gauges nearby, and also from month to month, making it not clear a relationship between dry/wet season and members of the ensembles. Finally, the research evidenced that all the individual models and the ensembles analyzed have a poor performance in subbasins in the upper part of the Magdalena-Cauca watershed caused by flow regulation (not accounted for in any of the hydrological models analyzed) and also due to a poor estimation of the forcing precipitation field for both, gridded in-situ data and reanalysis, in a high relief terrain with lack of rainfall stations.