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Large scale hydrologic models as well as land surface models require a large number of fine-tuned effective parameters per grid cell to be able to accurately predict variables of interest (e.g., streamflow, soil moisture) across locations and scales. Finding those sets of parameters has been an active area of research in hydrological sciences during the last decades. Up to date, many approaches exist but none is entirely satisfactory. This problem is drastically enhanced in large scale river basins due to the non-linear computational costs associated with increasing resolution and basin area.

In this study we demonstrate that the Multiscale Parameter Regionalization technique (Samaniego et al. 2010, WRR) applied to the mesoscale hydrologic model mHM 5.2 (www.ufz.de/mhm) is an effective method to find quasi scale invariant parameter sets (i.e., global regionalization or regularization multipliers) over 250 Pan-European river basins varying from 100 km^2 to 500 000 km^2. Two different parameter estimation strategies, single vs. multi-basin, are tested. In both cases, the Shuffled Complex Evolution algorithm is used to estimate parameters using the Kling-Gupta efficiency metric as an objective function.

Both single and multi-basin calibration strategies are tested with a number of performance metrics against observed streamflow, remotely sensed soil moisture (SM) and total water storage (TWS). The streamflow records are obtained from the GRDC repository (www.bafg.de/GRDC). The SM and TWS products are ESA-CCI with a spatial resolution of $(0.25 \times 0.25)^\circ$ (www.esa-soilmoisture-cci.org) and GRACE (Landerer and Swenson 2012, WRR; www.nasa.org) with a spatial resolution of $(1 \times 1)^\circ$.

In most cases, the single-basin optimisation strategy is the best alternative for a given basin but its transferability can not be guaranteed. The multi-basin technique is at least as good as the best cross-validated results obtained for the single-basin calibration using only streamflow. In general, 50% of the basins exhibit a NSE larger than 0.5 with the multi-basin strategy. An advantage of the multi-basin optimization technique is that it generates physically plausible fields of distributed variables such as soil moisture, which exhibit spatial continuity rather than a patchy distribution generated by numerical artifacts during the single-basin optimization. The multiscale parameterization technique allows to assimilate disparate information of available data sets (e.g., TWS, SM) on their native resolution. Cross validation experiments show that TWS in addition to streamflow in the objective function lead to the best results in terms of predicting observed streamflow. On the contrary, SM used with streamflow can not reproduce observed runoff dynamics adequately. From these findings it can be concluded that the available soil moisture product has limited information for inferring model parameters in large river basins.