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Constraining conceptual hydrological models with multiple information sources

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Calibrating hydrological models without stream flow observations is still difficult, and the simultaneous, combined use of additional data, such as remotely sensed products, for calibration has not been exhaustively tested thus far. It is hypothesized that the combined use of products can improve model performances, internal model dynamics and the representation of hydrological signatures, in comparison with traditional calibration on stream flow.

In order to cover a variety in climate, landscape and geography, a selection of 27 catchments across Europe was made, and five different conceptual hydrological models were applied here. A parameter selection process, similar to a likelihood weighting procedure, was applied for ten different data sources, ranging from using 1 to all 10 of these products, leading to 1023 possible combinations of the data sources. Probabilities of improvement, with respect to commonly applied model performance metrics, were determined when including a specific product for constraining. The performance of the models to reproduce 27 hydrological signatures was evaluated in a similar way with the probability of improvement relative to the unconstrained model.

Combinations that included AMSR-E and ASCAT soil moisture, GRACE total water storage anomalies, as well as, in snow dominated catchments, the MODIS snow cover products, showed high probabilities of improvement. The evaporation products of LSA-SAF and MOD16 were less effective for deriving meaningful, well constrained posterior parameter distributions. In addition, most models profited from constraining with an increasing number of data sources, as was shown by the hydrological signature analysis.

Concluding, constraining models with multiple data sources simultaneously was valuable for at least four of the five hydrological models to derive model parameters without the use of streamflow observations.