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A framework for spatial pattern oriented optimization of distributed hydrological models using satellite observations

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Currently, even distributed hydrological model evaluations remain focused on comparing simulations to a single spatially aggregated catchment scale observation in the form of river discharge, with the conviction that it provides insight into the internal hydrological behaviour of the river basin. This approach is outdated and suffers from a lack of spatial pattern evaluation which limits the credibility and justification of distributed models. However, hydrological model evaluation and calibration lack methodologies for incorporating spatial pattern information into the model optimization process.

This study addresses these limitations by developing and testing a framework for spatial pattern oriented model evaluation and parameter optimization. The framework is based on three elements, 1) Development of a new set of performance metrics that are designed for comparison of spatial patterns, 2) Generation of consistent spatial patterns of hydrological states and variables based on satellite remote sensing data sets, 3) Tailoring of the spatial model parametrization scheme to allow for pattern flexibility while minimizing the optimization problem.

The fundamental idea is, that while satellite remote sensing estimates of hydrological states and fluxes will inevitably be uncertain and hard to evaluate due to scale differences, they contain highly valuable information on spatial patterns that can provide the required basis for evaluating the spatial pattern performance of distributed hydrological models. By utilizing bias insensitive pattern metrics together with a flexible parametrization scheme, a distributed model is optimized using both traditional streamflow records and remote sensing based spatial patterns of evapotranspiration in isolation and in combination. The results reveal the importance of incorporating spatial patterns in the optimization in order to secure realistic simulated patterns and that when designed appropriately the trade-off between stream flow and spatial pattern performance is minimal.