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Evaluating spatial patterns in hydrological modeling

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Recent advances in hydrological modeling towards fully distributed grid based model codes, increased availability of spatially distributed data (remote sensing and intensive field studies) and more computational power allow a shift towards a spatial model evaluation away from the traditional aggregated evaluation. The consideration of spatially aggregated observations, in form of river discharge, in the evaluation process does not ensure a correct simulation of catchment-inherent distributed variables. The integration of spatial data and hydrological models is limited due to a lack of suitable metrics to evaluate similarity of spatial patterns. This study is engaged with the development of a novel set of performance metrics that capture spatial patterns and go beyond global statistics. The metrics are required to be easy, flexible and especially targeted to compare observed and simulated spatial patterns of hydrological variables. Four quantitative methodologies for comparing spatial patterns are brought forward: (1) A fuzzy set approach that incorporates both fuzziness of location and fuzziness of category. (2) Kappa statistic that expresses the similarity between two maps based on a contingency table (error matrix). (3) An extended version of (2) by considering both fuzziness in location and fuzziness in category. (4) Increasing the information content of a single cell by aggregating neighborhood cells at different window sizes; then computing mean and standard deviation. The identified metrics are tested on observed and simulated land surface temperature maps in a groundwater dominated catchment in western Denmark. The observed data originates from the MODIS satellite and MIKE SHE, a coupled and fully distributed hydrological model, serves as the modelling tool. Synthetic land surface temperature maps are generated to further address strengths and weaknesses of the metrics. The metrics are tested in different parameter optimizing frameworks, where they are defined as objective functions individually and collectively. Additionally discharge data, representing a different observational dataset, is included in the optimization process which enables a multi constrained evaluation of the model. This allows testing different optimization frameworks under consideration of observable spatial patterns and discharge data which represents a spatially aggregated catchment observation.