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Methods of Spatial Pattern Comparison for Distributed Hydrological Modelling

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The rigorous development, application and validation of distributed hydrological models obligates to evaluate data in a spatially distributed way. In particular, spatial model predictions such as the distribution of soil moisture, runoff generating areas or nutrient-contributing areas or erosion rates, are to be assessed against spatially distributed observations. Also model inputs, such as the distribution of modelling units derived by GIS and remote sensing analyses, should be evaluated against ground-based observations of landscape characteristics. So far, however, quantitative methods of spatial field comparison have rarely been used in hydrology.

In this paper, we present algorithms that allow to compare observed and simulated spatial hydrological data. The methods can be applied for binary and categorical data on regular grids. They comprise cell-by-cell algorithms, cell-neighbourhood approaches that account for fuzziness of location, and multi-scale algorithms that evaluate the similarity of spatial fields with changing resolution. All methods provide a quantitative measure of the similarity of two maps.

The comparison methods are applied in two mountainous catchments in southern Germany (Brugga, 40 km^2) and Austria (Löhnersbach, 16 km^2). As an example of binary hydrological data, the distribution of saturated areas is analyzed in both catchments. For categorical data, vegetation zones that are associated with different runoff generation mechanisms are analyzed in the Löhnersbach. Mapped spatial patterns are compared to simulated patterns from terrain index calculations and from satellite image analysis. It is discussed how particular features of visual similarity between the spatial fields are captured by the quantitative measures, leading to recommendations on suitable algorithms in the context of evaluating distributed hydrological models.