Geophysical Research Abstracts
Vol. 16, EGU2014-5268, 2014
EGU General Assembly 2014

Assessing spatial patterns to characterize performance in hydrological modeling

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In Hydrology, spatially distributed models are traditionally evaluated against a single spatially aggregated catchment scale observation in form of river discharge with the conviction that it features the correct simulation of catchment-inherent distributed variables. Recent advances in fully distributed grid based model codes, the availability of spatially distributed data (remote sensing and intensive field studies) and computational power allow a shift towards a spatial model evaluation away from the traditional aggregated evaluation. The need of this paradigm shift is demanded in literature; however no single spatial performance metric was identified yet that proofed suitable for comparing observed and simulated spatial patterns. The goal of this study is to develop and test simple and flexible metrics for assessing spatial patterns of distributed hydrological variables that go beyond global statistics. These metrics, individually or collectively can later be used as performance criteria in the calibration process of hydrological models. Observed and simulated land surface temperature, by the MODIS satellite and by MIKE SHE, a coupled and fully distributed hydrological model, respectively are used as a benchmark to test promising spatial metrics. Additionally a synthetic dataset which contains systematic temperature perturbations, e.g. a general bias or a shift/displacement of data, is generated to test strengths and weaknesses of the spatial metrics. Four quantitative methodologies for comparing spatial patterns are brought forward in this study: (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. All algorithms except (2) require subjective judgment: E.g. a distance decay function is utilized to compute the similarity values of neighborhood cells for the fuzziness of location. Therefore a web-based survey is set up where participants are asked to grade similarity of maps in the synthetic dataset. These results are used to calibrate the subjective parameters in the algorithms accordingly and to generally test how well the four algorithms can perform relative to the visual comparison.