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Calibration of a distributed hydrologic model using observed spatial patterns from MODIS data

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Distributed hydrologic models are typically calibrated against streamflow observations at the outlet of the basin. Along with these observations from gauging stations, satellite based estimates offer independent evaluation data such as remotely sensed actual evapotranspiration (aET) and land surface temperature. The primary objective of the study is to compare model calibrations against traditional downstream discharge measurements with calibrations against simulated spatial patterns and combinations of both types of observations. While the discharge based model calibration typically improves the temporal dynamics of the model, it seems to give rise to minimum improvement of the simulated spatial patterns. In contrast, objective functions specifically targeting the spatial pattern performance could potentially increase the spatial model performance. However, most modeling studies, including the model formulations and parameterization, are not designed to actually change the simulated spatial pattern during calibration.

This study investigates the potential benefits of incorporating spatial patterns from MODIS data to calibrate the mesoscale hydrologic model (mHM). This model is selected as it allows for a change in the spatial distribution of key soil parameters through the optimization of pedo-transfer function parameters and includes options for using fully distributed daily Leaf Area Index (LAI) values directly as input. In addition the simulated aET can be estimated at a spatial resolution suitable for comparison to the spatial patterns observed with MODIS data. To increase our control on spatial calibration we introduced three additional parameters to the model. These new parameters are part of an empirical equation to the calculate crop coefficient (Kc) from daily LAI maps and used to update potential evapotranspiration (PET) as model inputs. This is done instead of correcting/updating PET with just a uniform (or aspect driven) factor used in the mHM model (version 5.3).

We selected the 20 most important parameters out of 53 mHM parameters based on a comprehensive sensitivity analysis (Cuntz et al., 2015). We calibrated 1km-daily mHM for the Skjern basin in Denmark using the Shuffled Complex Evolution (SCE) algorithm and inputs at different spatial scales i.e. meteorological data at 10km and morphological data at 250 meters. We used correlation coefficients between observed monthly (summer months only) MODIS data calculated from cloud free days over the calibration period from 2001 to 2008 and simulated aET from mHM over the same period. Similarly other metrics, e.g mapcurves and fraction skill-score, are also included in our objective function to assess the co-location of the grid-cells. The preliminary results show that multi-objective calibration of mHM against observed streamflow and spatial patterns together does not significantly reduce the spatial errors in aET while it improves the streamflow simulations. This is a strong signal for further investigation of the multi parameter regionalization affecting spatial aET patterns and weighting the spatial metrics in the objective function relative to the streamflow metrics.