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Soil moisture parameter regionalization for a mesoscale hydrologic model

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Soil moisture is a key state variable in regional climate, hydrologic, and dynamic vegetation models. It is well recognised that the spatio-temporal distribution of soil moisture plays a crucial role not only on streamflow generation but also on many land-surface-atmosphere interactions on the mesoscale such as evapotranspiration during drying seasons, seasonal precipitation variability among others. Several regionalization and modelling approaches have been proposed in the literature, however, the state-of-the-art is not satisfactory in many aspects. Due to these reasons, this study focus on regionalization approaches for the soil moisture parameters of the hydrologic model (HBV-UFZ) and validation of the spatial patterns of soil moisture.

The HBV-UFZ hydrologic model is a spatially explicit, process-based mesoscale model driven by 6-12 h meteorological forcings (e.g. precipitation, temperature, and PET grids) and annual land cover grids. The size of the model grids vary from 100 m to 1000 m depending on the catchment size. This hydrologic model uses regionalized parameters whose nonlinear transfer function parameters are calibrated with multi objective adaptive simulated annealing. Specifically, soil moisture parameters are regionalized with combinations of basin descriptors such as slope, aspect, topographic wetness index, field capacity, porosity, and land cover.

To illustrate the application of the regionalization approaches, two southern German basins with an area of 120 to 4200 km^2 respectively are selected. This model is calibrated during the period from 1981 to 1990 and validated subsequently from 1991 to 2002. The validation results (e.g. Nash-Sutcliffe efficiency between 0.70-0.85) indicate that the model with regionalized parameters not only is able to reproduce dominant hydrologic processes (e.g. drought spells) but it is also able to reproduce reasonably well the spatial patterns of soil moisture. These patterns compare well against proxies derived from daily MODIS images (NASA) and antecedent precipitation index (API). Conditional spatial copulas between land surface temperature (LST) and modelled soil moisture (SM) indicate a strong inverse stochastic dependence, whereas the copulas between API and SM indicate a strong positive dependence, as expected.