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Spatial soil moisture patterns at basin scale using geostatistics

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First, we fully calibrated and validated the physically-based distributed hydrological model, GEOtop (Rigon et al. 2006), for the Little Washita watershed (583 km2), Oklahoma, USA, using SGP97 and SGP99 datasets. The energy fluxes (latent heat, sensible heat, net radiation, and ground heat), soil temperature profiles, soil moisture profiles, and streamflows were well-reproduced by the model in both calibration and validation. For more details see Bushara et al. (2010, EGU).
The high-resolution simulated volumetric soil moisture map for the top 5cm soil layer on July 12, 1997, was used as an input to study the spatial patterns of soil moisture, and to establish soil moisture measurement network in the watershed. The last rainfall event in the watershed before July 12 was on July 10, 1997. On July 12, the watershed was relatively wet. In moderately wet watersheds the soil moisture shows high degree of organization. Modeling results showed that soil type is the main controlling factor of soil moisture distribution in the watershed (Bushara and Rigon, 2010, EGU). Therefore, the proposed 240-soil moisture measurement points that form the soil moisture network were carefully selected in different soil types, and considering different soil moisture levels within each soil type.
Soil moisture patterns were studied using ordinary kriging (OK), and external drift indicator kriging (EDIK). The soil type is used as indicator for krigings, while the following indices: Digital Elevation Model (DEM), gradient, cosine aspect, wetness index, longitudinal curvature, soil depth, laplacian, slope, coordinates, river network, permeability, and their combinations were used as drifts (predictors) for EDIK.
Analysis of directional variogram of soil moisture showed that there is no anisotropy. Results show that all krigings reproduced unbiased soil moisture estimates. Although all krigings reproduced unbiased soil moisture estimates, OK, and universal kriging (UK), when the coordinates are used as predictors, reproduced very smoothed patterns and are very different from the actual patterns. The patterns reproduced using DEM, wetness index, soil depth, river network, permeability, and laplacian as predictors for EDIK, are similar to the patterns reproduced by the OK and UK. While using slope, gradient and cosine aspect as predictors for EDIK have clearly showed the patterns. The combination of all predictors except slope, river network, permeability, and coordinates for EDIK, reproduced the closest patterns to the actual patterns. Results show that the saturation excess is not the dominant runoff process in the watershed, and that the soil moisture patterns do not depend on vegetation distribution. The frequency distribution and variogram of soil moisture of the selected 240 points are very similar to the frequency distribution and variogram of the simulated soil moisture, respectively. The frequency distribution of the simulated soil moisture somehow showed to have bimodal distribution, while the frequency distributions obtained using all kriging algorithms showed to have normal distributions. Result shows that the closer the frequency distribution to the simulated frequency distribution, the better the reproduced the soil moisture patterns. Nevertheless, none of the above krigings is able to capture the extreme values of soil moisture. The residual soil moisture maps, as obtained from kriging cross validation, and the frequency distributions of soil moisture show that the 240-soil moisture measurement points are reasonably enough to establish permanent soil moisture network in the watershed.