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A comparison of the effect of land use, soil composition and topography on the energy fluxes in the Rur catchment

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As part of the MiKlip program on seamless decadal climate prediction, we study the effects of subsurface hydrodynamics and land cover on the land surface energy fluxes by analyzing the results of a fully coupled land surface-subsurface model, in a simulation performed over a computational domain that includes the Rur catchment, Germany.
The modeling system consists of the hydrologic model ParFlow, a 3D parallel watershed model that simulates surface and subsurface water flow, and of the Community Land Model CLM, which simulates physical, chemical and biological processes at the land surface. The atmospheric forcing is obtained from the weather prediction and climate model of the German weather service, COSMO.
A Model Complexity Reduction Approach is proposed to reduce the computational burden of fully coupled simulations, by running a simplified model over the entire domain over large spatial scales (on the order of 10^6 km^2) and applying corrections based on the results of the full complex system over smaller subdomains (on the order of 10^4 km^2) and similarity rules between the cells.
In order to develop the corrections, we analyzed individual and correlated impacts of vegetation cover, soil composition and topography on the energy fluxes at the land surface. We focused on the topographic wetness index (TI), as an indicator of the topographic structure and as a source of static information about the groundwater dynamics. With stepwise multivariate regression several correction functions for the evapotranspiration (ET) were found, for example, TI with water table depth, and for the temporally varying spatial correlations TI with water table depth and ET. This is based on characteristic locations in the watershed where moisture limitation reduces ET or moisture abundance along river corridors enhances e.g., transpiration. The temporal variability in the correlations stems mainly from the diurnal and seasonal cycles. Additional variables in the analysis may be land and soil cover, which are also useful in explaining a smaller part of the spatial variance. However, TI appears to be the primary predictor for the spatial variability of the exchange of energy between the subsurface, land surface and atmosphere in simulations and may play an important role in the complexity reduction approach developed in this study.