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Observed and simulated effect of plant physiology and structure on land surface energy fluxes and soil conditions

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The parameterization of stomatal conductance and leaf area index (LAI) in land surface models largely influence simulated terrestrial system states. While stomatal conductance mainly controls transpiration, latent heat flux, and root-water-uptake, LAI impacts additionally the radiative energy exchange. Thus both affect canopy evaporation and transpiration and land surface energy and water fluxes as a whole.

Common parameterizations of stomatal conductance follow either semi-mechanistic forms based on photosynthesis (Ball-Berry Type (BB)) or forms which consider environmental factors such as impact of light, temperature, humidity and soil moisture (Jarvis-Stewart Type (JS)). Both approaches differ also in the interpretation of humidity effects and light-use efficiency. While soil moisture plays an important role for root-water-uptake there is no clear conclusion yet about how soil moisture interacts with stomata activity. Values for LAI can be obtained from field measurements, satellite estimates or modelling and are used as an essential model input. While field measurements are very time consuming and only represent single points, satellite estimates may have biases caused by variable albedo and sensor limitations. Representing LAI within land surface models requires complex schemes in order to represent all processes contributing to plant growth.

We use the Terrestrial System Modelling Platform (TerrSysMP) over the Rur watershed in Germany for studying the influence of plant physiology and structure on the state of the terrestrial system. The Transregional Collaborative Research Center 32 (TR32) extensively monitors this catchment for almost a decade. The land surface (CLM3.5) and the subsurface (ParFlow) modules of TerrSysMP are conditioned based on satellite-retrieved land cover and the soil map from FAO and forced with a high-resolution reanalysis by DWD. For studying the effect of plant physiology, the Ball-Berry-Leuning, and Jarvis-Stewart stomatal parameterizations are implemented into the CLM3.5 version within TerrSysMP. Simulation results from both parameterizations are compared against the original Ball-Berry-Collatz model in the standard version of CLM3.5. Furthermore results using MODIS LAI are compared against simulations using a simple parameterization of LAI based on ground surface temperature. All simulation results are compared against Eddy Covariance flux and soil moisture network observations performed. A Taylor-diagram and other statistic methods including model performance indices are employed to compare the different parameterizations with the observations. The two way feedback between water table dynamics and energy fluxes is explored to evaluate the effect of vegetation input on energy and hydrologic state of the simulated terrestrial system.

Preliminary results show that the Jarvis-Stewart along with parameterized LAI performs well in simulating latent heat and sensible heat for grass and winter wheat type of land cover condition during 2012 except for some time period. While applying PF-CLM3.5 for coupled surface-land surface simulation, water table depth increases with the increase of transpiration. This result indicates stomatal control scheme in CLM3.5 is not sensitive to the reduction of soil wetness if the water table is relatively high. In this study changing stomatal scheme and LAI input can lead to high variability of resulting energy fluxes.