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Effect of vegetation physiology and structure on thermal and hydrological state in a coupled terrestrial system model

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When simulating the circulation of energy and moisture in the terrestrial system, vegetation is one of the key factors which affect energy and water fluxes at land surface and in the subsurface. Vegetation physiology in the terrestrial system includes transpiration, respiration, and root water uptake. One of the main vegetation schemes controlling transpiration in Land Surface Models is the empirical parameterization for stomatal conductance. There are two main types of stomatal conductance used in land surface models: the Jarvis-Stewart type based on environmental factors such as light use efficiency, temperature, vapor pressure deficit, and soil moisture limit: and the Ball-Berry type based on photosynthesis schemes with a semi-mechanistic parameterization. Moreover, the interconnection between soil moisture and stomatal conductance is not fully understood and needs further investigation. Alongside stomatal conductance, Leaf area index (LAI) also has a significant effect on the modelling system and thereby can impact the calculation of latent heat and sensible heat fluxes, ground temperature, and soil moisture. LAI represents the vegetation structure effects on the hydrological and thermal state of land surface by interception, albedo, and shading, and therefore altering transpiration and leaf surface evaporation. LAI can be obtained from observations such as field and satellite measurement; or estimated using parameterization in Land Surface Models and Dynamic Vegetation Models..

This study focuses on how different vegetation schemes of stomatal conductance and LAI input effect land surface energy fluxes and groundwater flow, and how the uncertainty of different schemes propagates to the calculation of thermal and hydrologic state of land surface and soil moisture. To reach the research aims of this study, land surface simulations and coupled land surface-groundwater simulations are performed and compared. In this numerical experiment, the modelling platform TerrSysMP is used. TerrSysMP consists of the regional circulation model COSMO, the land surface model Community Land Model 3.5 and the groundwater model ParFlow. An external coupler OASIS is used to run TerrSysMP in multiple coupling mode. ParFlow-CLM and standalone CLM are applied in this study in order to understand the interaction between vegetation and energy fluxes and water fluxes. Several different vegetation schemes of stomatal conductance such as Ball-Berry, Ball-Berry-Leuning, and Jarvis-Stewart types, as well as different LAI inputs such as MODIS LAI and a temperature-based LAI scheme are implemented and compared in this research. Sensitivity analysis is carried out to interpret how different vegetation schemes can affect energy and hydrologic fluxes in a real catchment.