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Impact of different degrees of detail in models of root water uptake on simulated seasonal patterns of evapotranspiration and soil moisture

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Plant water uptake is a crucial process linking water fluxes in the soil-plant-atmosphere continuum. Soil water extraction by roots affects the dynamic and distribution of soil moisture in the rooted zone. Water supply of plants controls transpiration, which is an important factor for the energy balance at the land surface and influences plant growth through its connection with photosynthesis. Effective algorithms for estimating root water uptake are therefore needed in crop and forest stand models, which are designed to predict plant growth and yield at the field and stand scale as well as in land-surface models, which act at larger scales and are designed to be coupled with regional climate models. According to differences in the resolution of the variables calculated by such models and due to the demands on the computational time, which is required to run these models, the degree of detail how root processes are represented varies considerably between such models. Moreover, recent studies at the single plant scale have shown that more sophisticated models of root water uptake, which consider explicitly architecture of plants and distinguish between the hydrological parameters of bulk soil and rhizosphere, can simulate effects of soil moisture deficit more realistically than less detailed larger scale models.

The present study aims on exploring the potential of improving large scale vegetation models, which are needed for regional climate modelling, by incorporating more detailed modelling approaches of root water uptake in it. As a first step, seasonal patterns of evapotranspiration and soil moisture in the rooted zone are simulated using three models differing in the degree of detail in calculating root water uptake: the Community Land Model (CLM), which can be coupled to atmospheric models, the root water uptake routine of the crop model CERES and a newly developed modelling approach, which considers explicitly plant architecture and soil water transport towards roots. The simulation results are compared with measured data originating from a lysimeter study with juvenile beech trees and from an experimental field site with winter wheat.