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Water balance measurements and simulations of maize plants on lysimeters

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In Central Europe expected major aspects of climate change are a shift of precipitation events and amounts towards winter months, and the general increase of extreme weather events like heat waves or summer droughts. This will lead to strongly changing regional water availability and will have an impact on future crop growth, water use efficiency and yields. Therefore, to estimate future crop yields by growth models accurate descriptions of transpiration as part of the water balance is important.

In this study, maize was grown on weighing lysimeters (sowdate: 24 April 2013). Transpiration was determined by sap flow measurement devices (ICT International Pty Ltd, Australia) using the Heat-Ratio-Method: two temperature probes, 0.5 cm above and below a heater, detect a heat pulse and its speed which allows the calculation of sap flow. Water balance simulations were executed with different applications of the model framework Expert-N. The same pedotransfer and hydraulic functions and the same modules to simulate soil water flow, soil heat and nitrogen transport, nitrification, denitrification and mineralization were used. Differences occur in the chosen potential evapotranspiration ET_{pot} (Penman-Monteith ASCE, Penman-Monteith FAO, Haude) and plant modules (SPASS, CERES). In all simulations ET_{pot} is separated into a soil and a plant part using the leaf are index (LAI). In a next step, these parts are reduced by soil water availability. The sum of these parts is the actual evapotranspiration ET_{act} which is compared to the lysimeter measurements.

The results were analyzed from Mid-August to Mid-September 2013. The measured sap flow rates show clear diurnal cycles except on rainy days. The SPASS model is able to simulate these diurnal cycles, overestimates the measurements on rainy days and at the beginning of the analyzed period, and underestimates transpiration on the other days. The main reason is an overestimation of potential transpiration T_{pot} due to too high simulated leaf area indexes (LAIs) at the beginning of the analyzed period. At the end of the measurement period, green LAI decreases and thus T_{pot} gets lower. At daily time steps transpiration simulated by SPASS agrees well with the measurements while CERES simulations overestimate Tact. Differences in ET_{act} simulations compared to the lysimeter measurements mainly occur due to the different choice of ET_{pot}-models.

In conclusion, with the help of canopy models the water balance of the lysimeter system can be reasonably well simulated. However, the applied crop models oversimplify plant water transport and thus may not describe the water uptake and hence crop growth dynamics well enough for application of expected future climate scenarios.