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Modeling climate change impacts on maize growth with the focus on plant internal water transport

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Based on climate change experiments in chambers and on field measurements, the scientific community expects regional and global changes of crop biomass production and yields. In central Europe one major aspect of climate change is the shift of precipitation towards winter months and the increase of extreme events, e.g. heat stress and heavy precipitation, during the main growing season in summer. To understand water uptake, water use, and transpiration rates by plants numerous crop models were developed. We tested the ability of two existing canopy models (CERES-Maize and SPASS) embedded in the model environment Expert-$N^{5.0}$ to simulate the water balance, water use efficiency and crop growth. Additionally, sap flow was measured using heat-ratio measurement devices at the stem base of individual plants. The models were tested against data on soil water contents, as well as on evaporation and transpiration rates of Maize plants, which were grown on lysimeters at Helmholtz Zentrum München and in the field at the research station Scheyern, Germany, in summer 2013 and 2014. We present the simulation results and discuss observed shortcomings of the models. CERES-Maize and SPASS could simulate the measured dynamics of xylem sap flow. However, these models oversimplify plant water transport, and thus, cannot explain the underlying mechanisms.

Therefore, to overcome these shortcomings, we additionally propose a new model, which is based on two coupled 1-D Richards equations, describing explicitly the plant and soil water transport. This model, which has previously successfully been applied to simulate water flux of 94 individual beech trees of an old-grown forest, will lead to a more mechanistic representation of the soil-plant-water-flow-continuum. This xylem water flux model was now implemented into the crop model SPASS and adjusted to simulate water flux of single maize plants. The modified version is presented and explained. Basic model input requirements are the plant above- and below-ground architectures. Shoot architectures were derived from terrestrial laser scanning. Root architectures of Maize plants were generated using a simple L-system. Preliminary results will be presented together with simulation results by CERES-Maize and SPASS.