EGU22-3466
https://doi.org/10.5194/egusphere-egu22-3466
EGU General Assembly 2022

Coupled modelling of hydrological processes and grassland production in two contrasting climates

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Projections of global climate models suggest that ongoing human-induced climate change will lead to an increase in the frequency of severe droughts in many important agricultural regions of the world. Eco-hydrological models that integrate current understanding of the interacting processes governing soil water balance and plant growth may be useful tools to predict the impacts of climate change on crop production. However, the validation status of these models for making predictions under climate change is still unclear, since few suitable datasets are available for model testing. One promising approach is to test models using data obtained in "space-for-time" substitution experiments, in which samples are transferred among locations with contrasting current climates in order to mimic future climatic conditions. An important advantage of this approach is that the soil type is the same, so that differences in soil properties are not confounded with the influence of climate on water balance and crop growth. In this study, we evaluate the capability of a relatively simple eco-hydrological model to reproduce 6 years (2013-2018) of measurements of soil water contents, water balance components and grass production made in weighing lysimeters located at two sites within the TERENO-SoilCan network in Germany. Three lysimeters are located at an upland site at Rollesbroich with a cool, wet climate, while three others had been moved from Rollesbroich to a warmer and drier climate on the lower Rhine valley floodplain at Selhausen. Four of the most sensitive parameters in the model were treated as uncertain within the framework of the GLUE (Generalized Likelihood Uncertainty Estimation) methodology, while the remaining parameters in the model were set according to site measurements or data in the literature.

The model accurately reproduced the measurements at both sites, and some significant differences in the posterior ranges of the four uncertain parameters were found. In particular, the results indicated greater stomatal conductance as well an increase in dry matter allocation below-ground and a significantly larger maximum root depth for the three lysimeters that had been moved to Selhausen. As a consequence, the apparent water use efficiency (above-ground harvest divided by evapotranspiration) was significantly smaller at Selhausen than Rollesbroich. Data on species abundance on the lysimeters provide one possible explanation for the differences in the

plant traits at the two sites derived from model calibration. These observations showed that the plant community at Selhausen had changed significantly in response to the drier climate, with a significant decrease in the abundance of herbs and an increase in the proportion of grass species. The differences in root depth and leaf conductance may also be a consequence of plasticity or acclimation at the species level. Regardless of the reason, we may conclude that such adaptations introduce significant additional uncertainties into model predictions of water balance and plant growth in response to climate change.