Geophysical Research Abstracts
Vol. 18, EGU2016-7825, 2016
EGU General Assembly 2016

How do alternative root water uptake models affect the inverse estimation of soil hydraulic parameters and the prediction of evapotranspiration?

Sebastian Gayler (1), Daisy Salima-Sultana (2), Benny Selle (3), Joachim Ingwersen (1), Hans-Dieter Wizemann (4), Petra Högy (5), and Thilo Streck (1)

(1) University of Hohenheim, Institute of Soil Science and Land Evaluation, Biogeophysics, Stuttgart, Germany (sebastian.gayler@uni-hohenheim.de), (2) Institute of Water and Flood Management, Bangladesh University of Engineering and Technology, Dhaka 1000, Bangladesh, (3) Beuth Hochschule für Technik Berlin, D-13353 Berlin, (4) Institute of Physics and Meteorology, University of Hohenheim, 70593 Stuttgart, Germany, (5) Institute of Plant Ecology, University of Hohenheim, 70593 Stuttgart, Germany

Soil water extraction by roots affects the dynamics and distribution of soil moisture and controls transpiration, which influences soil–vegetation–atmosphere feedback processes. Consequently, root water uptake requires close attention when predicting water fluxes across the land surface, e.g., in agricultural crop models or in land surface schemes of weather and climate models. The key parameters for a successful simultaneous simulation of soil moisture dynamics and evapotranspiration in Richards equation-based models are the soil hydraulic parameters, which describe the shapes of the soil water retention curve and the soil hydraulic conductivity curve. As measurements of these parameters are expensive and their estimation from basic soil data via pedotransfer functions is rather inaccurate, the values of the soil hydraulic parameters are frequently inversely estimated by fitting the model to measured time series of soil water content and evapotranspiration.

It is common to simulate root water uptake and transpiration by simple stress functions, which describe from which soil layer water is absorbed by roots and predict when total crop transpiration is decreased in case of soil water limitations. As for most of the biogeophysical processes simulated in crop and land surface models, there exist several alternative functional relationships for simulating root water uptake and there is no clear reason for preferring one process representation over another. The error associated with alternative representations of root water uptake, however, contributes to structural model uncertainty and the choice of the root water uptake model may have a significant impact on the values of the soil hydraulic parameters estimated inversely.

In this study, we use the agroecosystem model system Expert-N to simulate soil moisture dynamics and evapotranspiration at three agricultural field sites located in two contrasting regions in Southwest Germany (Kraichgau, Swabian Alb). The Richards equation combined with the Mualem-van Genuchten approach to parametrize the soil hydraulic functions was coupled to three different root-water uptake modules according to Nimah & Hanks, Feddes, and van Genuchten. Potential evapotranspiration was estimated following Penman-Monteith, whereas leaf area index and rooting depth were predefined model inputs derived from observations. Simulation results were compared to 3-year time-series of time-domain reflectometry measurements of soil moisture in two to five different depths (depending on solum thickness) and eddy-covariance measurements of evapotranspiration. Data of two growing seasons (2010, 2011) were used for the inverse estimation of saturated water content, saturated hydraulic conductivity and the van Genuchten parameters α and n using the universal optimization tool UCODE. Data from the growing season 2012 were used for model validation.

The model calibration results showed a similar and acceptable goodness of fit between simulated and observed soil water contents and actual evapotranspiration for all there models. There was no substantial difference in model performance between the alternative root water uptake models during the calibration phase 2010-2011. However, the values of the optimized soil hydraulic parameters substantially differed in some cases, resulting in an increased model uncertainty during the prediction phase 2012, especially during phases of strong drying out of the soil. Albeit single model combinations are superior over the others for single locations with respect to the different observables (soil moisture, evapotranspiration), none of the models outcompeted the others over all years, locations and observables. We conclude that model solutions cannot be considered unique when different process representations are selected and the respective soil hydraulic parameters fitted (equifinality problem).