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Macroscopic root water uptake distribution using a matric flux potential approach

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Introduction.

During soil water depletion, when hydraulic conditions turn from nonlimiting into limiting, transpiration decreases with soil water content. In the Soil-Water-Atmosphere-Plant simulation model (SWAP, 2006), potential water extraction is partitioned over depth, proportional to the root length. An empirical water stress reduction function proposed by Feddes et al. (1978) is applied at each layer to estimate the reduction in water uptake. This methodology does not allow for compensation of uptake restrictions from a drier layer through an increase in uptake from a wetter layer. The objective was to develop a more physically based extraction model with an implicit compensation mechanism, incorporate it into SWAP and test it against experimental data.

Materials and Methods.

A shape function for the Matric Flux Potential (M) and the radial distance from the root surface was found through numerical analysis (De Jong van Lier et al., 2006; Metselaar & de Jong van Lier, 2007). Based on this function, and assuming a constant value of M at the surface of all roots, root extraction per layer can be shown to be a function of layer bulk M, root surface M and a weighting factor that depends on root density and root radius alone. Actual transpiration can thus be calculated from the sum of extraction per layer. This proposed reduction function (PRF) was built into SWAP and model predictions were compared to those with the Feddes et al. (1978) reduction function (FRF). Simulation results using both FRF and PRF were compared with an 18 year data set from Swift Current, Canada (continuous spring wheat) and with a 4 year data set from Hanover, Germany (spring wheat, winter barley, sugar beets, winter wheat rotation).

Results, Discussion, Conclusions.

For Swift Current (number of observations n = 142), the normalized root mean square error (*NRMSE*) was very similar for both the FRF and the PRF in the upper two soil layers (015 and 1530 cm). For the deeper layers, *NRMSE* was smaller for the PRF than for the FRF. Especially below 60 cm, the PRF appears to give significantly better estimates of water content than the FRF: 52% vs. 77% in the 60-90 cm layer; 48% vs. 69% in the 90-120 cm layer. At the Hanover site (number of observations n = 82), the values of *NRMSE* were lower for PRF in the upper soil layers (20 and 40 cm). For the deeper layers, *NRMSE* was of the same magnitude for both FRF and PRF.

In conclusion, the incorporation of the new reduction function into SWAP was successful, allowing the inclusion of compensation of uptake from wetter layers without increasing the number of empirical input parameters. Model performance remained the same or improved, as evaluated according to the NMRSE for two data sets.

References

De Jong van Lier, Q, K. Metselaar, and J.C. van Dam. 2006. Root Water Extraction and Limiting Soil Hydraulic Conditions Estimated by Numerical Simulation. Vadose Zone J., 5:1264-1277.

Feddes, R.A., P.J. Kowalik, and H. Zaradny. 1978. Simulation of Field Water Use and Crop Yield Simulation Monograph Series. PUDOC, Wageningen.

Metselaar, K., and Q. De Jong van Lier. 2007. The shape of the transpiration reduction function under plant water stress. Vadose Zone J., In Press (#V06-0086).

SWAP, 2006. Link to the reference version of the model used in this paper http://www.swap.alterra.nl/