Geophysical Research Abstracts
Vol. 15, EGU2013-10744-3, 2013
EGU General Assembly 2013

A new model of root water uptake including rhizosphere dynamics

Eva Kroener and Andrea Carminati
Soil Hydrology, Georg-August University Goettingen, Germany (eva.kroener@forst.uni-goettingen.de)

To understand root water uptake it is essential to look at the soil-root interface: the narrow region of soil close to the roots, the so-called rhizosphere, contains microorganisms, bacteria and fungi. It is influenced by root secretions and mucilage, a polymeric gel that alters the hydraulic properties of the rhizosphere.

Here a conceptual model will be presented that describes the hydraulic behaviour of the rhizosphere. Most existing models of root water uptake regard the soil around roots as a homogeneous medium - i. e. rhizosphere and soil are assumed to have identical properties. However, recent experiments ([2]) demonstrated that there are certain hydraulic behaviours of the rhizosphere that could not have been observed in homogeneous soils. This difference can be explained by the jellylike consistency of mucilage: A characteristic property of gels is that they swell and shrink with increasing and decreasing water potential. Swelling and shrinking of gels result in rhizosphere hydraulic properties that vary over time.

Carminati ([1]) has proposed such a model for the relation between water potential h and water content θ:

$$\frac{\mathrm{d}\theta_{rh}}{\mathrm{d}t} = C_{rh}(\theta_{rh})\frac{\mathrm{d}h_{rh}}{\mathrm{d}t} + \Gamma_{rh}(\theta_{rh})\,(h_{rh} - h_{rh}^{eq}) \ , \quad (1)$$

where the index rh refers to the rhizosphere, C_{rh} is the specific soil water capacity and Γ_{rh} is a proportional coefficient that characterizes the wetting rate of the rhizosphere. Γ_{rh} as well as C_{rh} depend on the water content. In this equation water content and water potential are decoupled, allowing partly independent temporal changes of θ and h.

In the presented work a radial model of root water uptake is introduced that is based on the Richards' equation. The Richard's equation is modified in such a way that θ and h are decoupled, so that equation (1) can be included in the model.

In order to guarantee a smooth transition between the hydraulic properties of the bulk soil and the region at the root surface a weighting factor $c_2(r)$ is introduced that balances the two terms in equation (1):

$$\frac{\mathrm{d}\theta}{\mathrm{d}t} = c_2(r)\,C(h)\frac{\mathrm{d}h}{\mathrm{d}t} + [1 - c_2(r)]\Gamma(\theta)\,(h - h^{eq}) \ , \quad (2)$$

where $\Gamma_{rh}(\theta_{rh}) = c_0\,\theta^{c_1}$ is parameterized by the constants c_0 and c_1 and

$$c_2(r) = (r - r_0)/(r_1 - r_0) \text{ if } r < r_1 \quad (3)$$

with r_0 being the root radius and r_1 the rhizosphere radius. For $r \geq r_1$, $c_2(r) = 1$.

This model is implemented numerically in radial coordinates and the results are compared qualitatively to experiments ([2]): on the one hand the model predicts that the rhizosphere remains wetter than the adjacent bulk soil during root water uptake - which is certainly a benefit for plants when the soil becomes dry. On the other hand it can reproduce that if a dry soil is irrigated the rhizosphere remains dry for a longer time than the bulk soil - which instead could be a drawback during the rewetting phase.

[1] A. Carminati. A Model of Root Water Uptake Coupled with Rhizosphere Dynamics. *Vadose Zone Journal*, 11(3), 2012

[2] A. Carminati, A.B. Moradi, D. Vetterlein, P. Vontobel, E. Lehmann, U. Weller, H.J. Vogel, S.E. Oswald. Dynamics of soil water content in the rhizosphere. *Plant and Soil*, 332(1):163-176, 2010