Dear Prof. Ursino,

Thank you for the handling of our manuscript and the guidance of the review process. On behalf of all Co-Authors we hereby want to put up the revised version of our manuscript for discussion.

We carefully reviewed and edited the entire manuscript in order to treat all issues raised during the review process. All changes applied to the manuscript are emphasized by color highlighting. Within the following, we want to give a brief overview over the major points that were clarified in the revised manuscript. We additionally attached a detailed summary of the review process as a supplementary to this letter.

> *„THE HYDRODYNAMICS OF ROOT UPTAKE*
>
> *The constant value of transpiration, the absence of redistribution, a schematic representation of root architecture, soil and soil moisture homogeneity lessen the correspondence between your conceptual model and reality. Root architecture determines the connection between the plant and different soil depths, where the boundary conditions for the root uptake dynamics may be very different (as pointed by AR2). To which extent, focusing on root resistance only may misrepresent the real world water use efficiency, should be stated clearly."*

We are aware that some of our other assumptions are unrealistic. However, a schematic representation of the root architecture and the absence of soil water redistribution are only assumed within the simple model. The complex „aRoot" model incorporates both „realistic" root geometries (provided by the external root generator „RootTyp" by Pagés et al. (2004)) and redistribution of water. Soil water flow is numerically calculated with a finite element method solving the three-dimensional Richards equation (Kalbacher et al., 2011; Kolditz et al., 2012)), root hydraulic redistribution occurs in the aRoot model. The qualitative results obtained with the simple model are not only reproduced in the aRoot model, they can also serve to understand the results at a higher level of model complexity.

A constant value of transpiration was used as it allows a simple interpretation of our results: Together with a drying scenario, a constant transpiration rate causes the collar potential to decrease monotonically along with the soil water potential. Only in this specific case the occurrence of water stress is unique. We use this unique point in time to define unique values of our indices „water yield“ and „effort“. Moreover, a simple calculation shows that (only) in this specific case, effort is not only a flux weighted, but can simultanoeusly regarded as a time average collar potential.

“THE DEFINITION OF INDEXES

According to your reply to AR1 the interrelation between “effort” and “yield” should be declared. The disagreement with AR1 seems to originate from previous literature definition/interpretation of the concepts behind indexes. I think that the reader deserves to know what is new in your definition of yield, why you need to introduce effort instead, if there is a correlation between the two indexes (as stated by AR1) and to which extent this correlation is due to your simplifying modeling assumption (constant value of transpiration, the absence of redistribution…).”

We made a big effort to enhance the explanation and motivation of our indices in the revised manuscript as follows:

The first index „water yield“ v(t) (m^3/m), measures the „benefits“ of root water uptake. It assesses how much water V (m^3) could be taken up per unit root length under unstressed conditions within a given time. We normalize by total root length in order to obtain uptake per invested meter root length, and in order to correct for the increased soil water reservoir available to longer roots. As we neglect storage capacities within the root system, the volume of root water uptake equals the actual transpiration at all times.

The second index „effort“ w(t) (m) measures the physical quantity that refers to „costs“ of the overall root water uptake process: the specific amount of energy that was necessary per unit of root water uptake. It can equivalently be given in terms of a hydraulic head (m) or a specific energy (J/m^3).

As stated by the editor, the root hydraulic architecture (including root geometry and the distribution of root hydraulic properties) determines the interconnection of different soil depths with transient water potentials. Therefore, the energy necessary for water uptake and consequently also the index „effort“ does not only depend on the root hydraulic resistance alone, but beyond that on the entire soil-root-continuum. Both of our indices „effort“ and „water yield“ of course depend on plant hydraulic resistance, and we believe that this common dependence causes the correlation between those two. The question under which soil hydraulic conditions root hydraulic resistance is the dominating term in effort was not in the scope of this research and should be covered by another, intensive modeling study..

“ACCURACY OF RESULTS

The link between numerical discretization and model outcome must be clarified according to your reply to AR1.”

In contrast to „plant hydraulic resistance“, „effort“ has an optimum with respect to root length and the number of segments we used in the model is sufficient to prevent us from artifacts. Within the revised version of our manuscript we added the number of segments both in the Methods section (page 9, lines 4-6) and in the list of model parameters. Additionally, our results remain qualitatively the same under a sinusoidal day-night-cycle However, interpretation of the results is hampered in this specific case as water stress occurs and disappears successively.

“MAIN CONCLUSIONS AND LINK TO REALITY

The index analysis based on the concepts of axial and radial limitation, suggests that an optimum root development strategy could exist. As suggested by AR2 you could point out if there is any experimental evidence that corroborates your findings or even just the basic assumptions in your conceptual model.“

It is important to state clearly, that we present a modeling study which aims not at predicting actual root water uptake patterns. Instead, we aim at assessing what influence the distribution of root hydraulic properties may principally have on the efficiency and spatiotemporal dynamics of root water uptake, and what are the shaping parameters. We are not aware of experimental studies that support our findings directly. However we want to give some references that indicate for the sensibility of our results.

The partitioning of root functioning is promoted by the different root hydraulic properties that were measured on a variety of plants (Frensch and Steudle, 1989;Steudle and Peterson, 1998;Doussan et al., 2006;Bramley et al., 2007) and the variety of root topologies that can be observed.

Recently, spatial distribution of root water uptake in lupine root systems was estimated using neutron radiography by Zarebanadkouki et al. (2013). Their experimental setup is very similar to our modeling assumptions. In particular, the root topology of the lupines is very similar to the branched root modules used in our simple model. In accordance with our findings, the tap root takes up less water than the laterals, which indicates its functioning as a transport root. Water uptake is higher near the branching points compared to the root tips which indicates „hydraulic isolation". Finally, water uptake from shallow soil layers is higher than in greater depths. These observed uptake dynamics correspond well to our model results.

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