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## Comment on hess-2021-14

Anonymous Referee #1

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Referee comment on "From hydraulic root architecture models to macroscopic representations of root hydraulics in soil water flow and land surface models" by Jan Vanderborght et al., Hydrol. Earth Syst. Sci. Discuss.,  
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Review of article "From hydraulic root architecture models to macroscopic representations of root hydraulics in soil water flow and land surface models" by Jan Vanderborght et al.

Submitted to HESS, MS No.: hess-2021-14

### General comments

This article describes how water flow within a root system which can be described in a global matrix form, can be decomposed into different matrix representing different processes: distribution of contribution of total uptake of each root segments, redistribution of water flow within the root system (in case of heterogeneous soil water potential). This can be done if root system is represented as a set of resistive links (radial and axial) for water flow. If this set of links is supposed to represent the root system hydraulics, then it can be applied at any scale from a fine description of root system architecture (microscopic) to very coarse 1D 'a priori' description of root system (macroscopic), compatible with 1D description of water flow in soil, as done in surface model schemes. This work extends previous works of authors. I found very interesting this work, which rigorously provides a "natural" upscaling of root system hydraulic properties. It will be very useful for modelers to go deeper in the necessary use of root properties in sounded "effective" representation of root systems for water transfer and uptake in soil.

I think however, that the paper is a bit hard to follow at some times, even if the authors try to explain their derivation. The matrix notation (in particular for range indices) shall be explained. The central notion of Heff must be better explained. As presented, it appears as an added variable to the system. I found that section 4.1 was lengthy, and also rather

difficult to follow as notation of different "equivalent" root systems is not "fixed" and references to figures and tables to be better done. This could be rearranged according to type of studied model. Some explanations on differences of behavior between models (in section 4) are a bit confusing. I found much more interesting section 4.3 compared to 4.1 + 4.2. In all the examples shown, I questioned myself if conclusions would be the same if an imposed water outflow (transpiration) had been used in place of xylem potential collar, as often the case in a 1D model. Could this possibly impact the derivation of equations and water redistribution? A few words about this (in conclusion) would be welcome. Always in the conclusion, regarding "bottom-up" approach, I fully agree concerning integrating better knowledge of root architecture, but this should be balanced by the fact that (i) it is difficult to get distribution of root conductance (axial and radial) for a range of species, (ii) what about root growth/decay and associated parameterization and, finally (iii) if LSM (land surface models) are to deal with a mix of species, types of vegetation (e.g. grass, trees...), what would be needed ?

### **Specific comments**

L21 ... "the big root model" : not very clear for an abstract

L54-57 axial and radial conductivity and "the root radial conductance per root surface area; the axial conductivity per root cross sectional area" are essentially the same, may be better to express that root conductance are scaled to root surface area and root cross sectional area

L50-65: precise how is defined a root system in the big and parallel root approaches: a root density as a function of depth ?

L94 the axial conductance may limit the water absorption at the distal ends of roots: could be not clear for the reader : do you mean that water uptake is limited to the distal end or that water uptake decrease from proximal to distal part

L98 water absorbance : water uptake ?

L137 hydraulic head, Hcollar: specify unit of Hcollar : (L)

L140 Normaly, if considering water head unit for xylem potential, units for  $K_x$  should be  $L^3/T$  and for  $K_r$   $1/T$  – May be specify that conductance doesn't consider here surface and length of root segments

Eq5: specify for vector  $[0 \ Q]$  that 0 is  $N+1$ , and  $Q$  is  $N$  length

L161 may be specify that  $\text{diag}(K)$  stands for showing a diagonal matrix, based on a vector  $K$  where the  $N$  first elements are  $Kx(i)$  and the others  $Kr(i)$

L161 add a dot before  $\text{diag}(K) \Rightarrow \text{IMT} (2N_{\text{root}} \times 2N_{\text{root}}+1) \cdot \text{diag}(K)$

L173 specify that  $\text{SUF}[i]=Q[i]/Q_{\text{tot}}$

L173 Specify what means  $H_{\text{eff}}$  : what is an "effective" soil water potential around roots ?

L175-180: the aim of deriving the equations shall be given before (eg after eq 6), introducing the idea of defining  $H_{\text{eff}}$  whether  $H_{\text{soil}}$  is constant or not. As presented now the derivation is not very easy to understand...

L178.. write the equation of the weighted average

L179-180 the sum of the fluxes of the second term...: not easy to understand, may be add :  $\sum_i (C4(I,j) (H_s(i)-H_{\text{eff}}(i)) = 0$

L180 .. "The second term on the right-hand side represents the amount of water that is taken up more (less) by a certain root node than in case the soil water.... " : may be rephrase for more clarity with something like : on right-hand side represents the increase (decrease) in amount of water that is taken up by a root node when  $H_{\text{soil}}$  is higher (lower) relative to  $H_{\text{eff}}$

L211 conductance from root node  $i \Rightarrow$  conductance from node

L203-212 : not easy to follow...

L217-221 : not easy to follow... Useful here ?

Figure 3: Possibly, add in the figure the limits of soil layers in order for the reader to make a link between subfigures and number / distribution of hydraulic resistances.

L271 : precise that your figure 3 shows some equivalent, upscaled root system where root are distributed along 4 soil layers.

L276 "comes down to a top down parameterization" : ? meaning ?

L281 "Parallel root ... parameters... is equal to  $n_{depths}+1$ " : (i) isn't it  $n_{depth}$ ? Why +1 ?  
(ii) There are 2 parallel root models , could you annotate them differently, e.g. parallel -axial and parallel-no-axial (or parallel -Kx and parallel-Inf) to differentiate them. We often get lost in your description of different models...

L282 "requires  $2n_{depth}$  parameters": requires 2  $n_{depth}$  parameters

Table2 Why 4 digit for  $SU_f$  except for Parallel root system, which does not exactly sum(s) to 1; eg  $SU_{fupscale}$  of hybrid-parallel-big at the first depth is 0.406, not 0.3988. Specify in the legend that root hydraulic conductances are constant along roots

Table 3 in the legend specify that  $K_r=0.1$  along roots except at root tip  $K_r=1$

Figure 2: change the place of the legend box

L299-300: add a reference to table 2, this is true for the constant conductance example, not the other.

L303-304 No real underestimation of uptake figure 2 on proximal segments but rather overestimation at distal end from fig 2 ! please check.

L304-305: On fig 3 this follows more less the same pattern as figure 2 but with less discrepancy.

L305-306: Is it useful here? where do we see this equality which is not the really the case from table 2.

L314 implies that redistribution flow => implies that redistribution of flow

L325 in these layers soil => soil layers

L324-327: hard to follow.....

L354-355: conductance have now units which differ from their previous definition. It would be good to clarify the text with more adequate and explained words: conductance: when there is no normalization by geometry (ie length or area), conductivity when geometry normalized (as the case of these lines). "Intrinsic" conductivity is, classically in the field of porous media flow, related to conductivity of the matrix only, independently of the fluid...

L357-358 the roots was assumed... with 1 cm long... : => rather the "reference " exact model was based on a root 50 cm long discretized with 1 cm long root segments of uniform...

L358 The soil collar potential: ??? the water potential of root collar

L361 As to be expected => As expected, due to the series-pathway of water,

Figure 6a: distribution of hydraulic conductances is given as function of age, but in the text and result a distribution as function space (depth) is considered. A distribution of conductance as function of root collar distance would be rather needed here

Figure 7 : Sink term (in legend and axis) => Root sink term

Figure 8 Specify for which model are these figures (parallel—Kx)

L364-376: That the parallel model with distribution fluxes behaves well, and better than parallel infinity is not really surprising. And all this section could be shorten...

L396 Why did you choose these 3 root systems ? which main differences ? add a reference to figure 9 here

L410 cross the layer is calculated... => cross the layer  $i$  is calculated

L415 ...as above..., as in section 4.1 ?

L417-418 of the radial root segment conductance... => radial root segment conductance upscaled as in the big root model

L421 to parameterize hydraulic root water uptake => to parameterize hydraulic macroscopic root water uptake

L431 but is more outspoken => ?? but the difference is amplified

L433 add a reference to figure 10 here

L434 an overestimation ... distal ends of roots=> (i) there is no distal end of roots here but rather only soil depths, (ii) there is only a slight overestimation at depth, overestimation occurs at shallower to mid depth for maize and sunflower and seem not be related to a variation in distribution of roots in figure 9...

L435 opposite was observed => mostly for sunflower, for other plants only slight variations

L435-444 May be a more straightforward and concise interpretation, given the difference between the maize and sunflower, would be that as root act in parallel in a layer , and that most roots are laterals of lower conductance, this leads to higher SUF at shallower depth compared to greater depth

Figure 11 to which model (big root ?) refer these figures?

L452 The parallel root model => Which one, the parallel with  $K_x$  ?

L453 – 455 I can't understand the meaning of this sentence, which model is on figure 11?

L455 impact of approximations of Kcomp and the C7 matrix... of the parallel Kx model?

L472 RSA is not defined...

L491 LSM is not defined..

Appendix

Eq A3 and connectivity matrix: may be state that  $IM(i,j)=0$  if I and j are not connected and what about  $IM(I,j)$  if j is a proximal node of I ?

Eq A10 verify indices of matrix C that should be  $C[Nr+1:2Nr, 2Nr+1]$

Eq A14 verify indices of CL3 matrix, this rather be  $CL3[N+1:2N, N+2, 2N+1]$

L603 in "Considering Eq. [A 31], we can write:", may be better "indeed, when considering..."

In A38 What is ones ?

L638 add also that  $SUF\_T Heff = Heff$  to get A40

L656 What means "are connected more strongly"