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Hydrology and
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Discussions

Interactive comment on "Parameterizing complex root water uptake models – the arrangement of root hydraulic properties within the root architecture affects dynamics and efficiency of root water uptake" *by* M. Bechmann et al.

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Reply to reviewer #1, answer from referee 1

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1 Introduction

[1] First of all, we would like to thank the anonymous referee #1 for the repeatedly fast replies and intensive examination of our manuscript. The comments helped us a great deal to identify shortcomings in our manuscript and they will greatly contribute to improving it. In our last response we addressed some concerns of anonymous referee #1 , which we said were based on misunderstandings. We did not mean to blame the reviewer for the misunderstandings. It goes without saying that we as authors have to do our best to avoid misunderstandings in a manuscript. We found many comments very helpful, and will apply them in the next version.

[2] In our last response, we commented on major issues raised by the editor, thus omitting other comments of the reviewer, which we find really useful and which we will incorporate in the new manuscript. We believe with the last response, some of the major issues have been cleared up. In an effort to organize the discussion, we will visit them again, disentangle, where the agreement with the reviewer lies and address the disagreements. We will start with major issue #1 followed by #3 and #2. We than discuss the functional form of effort. Finally we respond to some comments which we could not fit under the other subheadings.

[3] Please note that the Figures and Appendices are uploaded separately as supplementary material.

2 Major issue #1: Applicability of the efficiency measures to transient root uptake scenarios

[4] The editor asked us to clarify whether or not our efficiency measures were only applicable to time constant root water uptake. This was addressed in the first section of our last note. Both water yield and effort are applicable under arbitrary boundary conditions. The reviewer raised some more points related to this issue.

[5] In “RC C204 Answer from referee to SC C145 #1” the reviewer points out that the notation and definition for the index effort changed between our short note and the initial manuscript, leading to different characteristics. This is not the case. The equation stated is already part of the discussion paper (Eq. A3), but it is admittedly really hidden. We agree that the derivation in the appendix is confusing and needs to be improved. In the revision we will first explicitly introduce the general case (we will refer to it as w(t)), which is valid for transient conditions and second show how we apply it in our paper to a scenario with constant water uptake. We thank the reviewer for pointing out this deficiency.

[6] The reviewer further remarks in his last answer:

> *“In figure 1 (c) of the answer to anonymous referee #1 , the calculation of effort is indeed not limited to the period before water stress, for the time variable flux condition. However, in the same figure, but for the constant flux condition, water potentials after the onset of water stress are not used in the calculation of effort (otherwise effort would continue increasing after the onset of water stress).”*

Indeed, the effort **does** further increase after the onset of water stress, but too slowly to be distinguishable in Fig. 1a of “SC C145 Note to referee #1” . The slower increase is caused by the decaying overall transpiration rate under the time constant boundary

condition $\psi(\tau) = \psi_{Crit} = -150m$. This is depicted in Fig. SC2.1 of this reply, and an interpretation of the underlying mathematics is attached in Appendix 1.

[7] In our response and in the manuscript, we claim that the results for water yield and effort are similar between the transient and the time-constant boundary condition. The reviewer remarks:

> *“Water yield is also said to be “related to the amount of water that can be taken up by the root until the onset of water stress”. If this is true, the water yield of the young root system under variable flux condition (see its collar water potential in Fig. 1 (b)) must be less than 0.075 times the water yield of the same root system under constant flux condition. However, the authors say in the manuscript and repeat in their answer to anonymous referee #1 , that the variable flux condition does not affect the results as compared to the constant flux condition. How is that even possible? ”*

Similarly as for effort, we will differentiate between the general case, which is also valid for transient conditions, and the case specifically applied in the manuscript, as suggested by the reviewer. We will further change the wording in the revised manuscript to “water yield is related to the amount of water that can be taken up under unstressed conditions”. Only for a time constant flux boundary condition, this is equivalent to “. . . before water stress occurs”, and we should have distinguished this in the response. Fig. SC2.2 of this reply demonstrates how water yield was calculated for a sinusoidal transpirational demand. Whenever limitation occurs, the water yield remains unaltered. But as the transpirational demand decreases in the afternoon, limitation disappears and water yield increases again. We will also indicate the evaluation period (15 days in the discussion paper). Finally, we will specify in the manuscript that the absolute values of water yield and effort differ between the transient and time-constant case, but not the order between the compared scenarios.

[8] In “RC C40 Referee comment by anonymous referee #1” , the reviewer further

strongly criticizes the different and confusing references to the index effort. We agree with the reviewer, that the introduction of this index as well its references in the text need to be improved. We will carefully revise the paper for these issues.

[9] We believe that in general and with the given necessary improvements to how the efficiency measures are introduced in the manuscript, this major issue could be cleared up: Both efficiency measures (yield and effort) do not depend on the transpiration being time constant.

3 Major issue #3:The concept of "axial limitation"

[10] We included this issue in the first response, because we felt that it was an important point of disagreement between ourselves and the reviewer. It is closely related to the questions of how and if at all our efficiency index “effort” relates to plant resistance and whether our background section covers a wrong concept.

[11] In particular our argument that plant resistance changes during the uptake process is a most prevalent point of disagreement between ourselves and the reviewer. In order to support our assertion that the total plant resistance depends on the water distribution surrounding the root and therefore changes over the course of water uptake, we calculate root water uptake in unbranched root strands using an analytical solution we derived from Couvreur et al. (2012). However, we would like to point out that already Landsberg and Fowkes (1972) showed that the root resistance changes depending on the distribution of water within the soil (remarks to their Eq. 18). After discussion of the root resistance, we will return to the definition of axial limitation in our background section, which we agree needs improvement.

[12] The reviewer argues that overall plant resistance (inversely conductance) is independent of the distribution of water along the root:

> *“In no way the distribution of soil water potentials or water flow in the architecture will change the overall conductance as long as local hydraulic conductances and their connections do not change. The arguments developed by the authors in page C151 of their answer to referee # 1 are a pure nonsense, the moving uptake front does not impact the overall hydraulic resistance of the root. In case roots of the same length also have the same architecture, local hydraulic properties and number of segments in figures 2 (a) and 2 (c), then they also have the same overall hydraulic resistance.”*

[13] We agree with the reviewer that material properties of the root, such as resisitivities do not change depending on the state of water in the soil. We disagree about the resistance, see below.

> *“The figure included in my previous comment illustrates overall hydraulic resistances calculated from Thevenin theorem (Thevenin, 1883), but could as well be calculated by dividing the water potential difference between root collar and soil by the transpiration rate (which can be done from figure 2 (a)).”*

[14] We believe the reviewers previous two statements can be summarized as follows: There exists a resistance, which represents the entire root network. This resistance is a property of the root network and does not change depending on the water distribution surrounding the root. It can be calculated using the Thevenin theorem.

[15] We disagree with the reviewer on the following point: We do not believe that the Thevenin resistance represents the total root system resistance, when soil water potential is distributed heterogeneously around the roots. We substantiate this in the following.

[16] We agree that the plot in Fig. 2a of our last short comment allows the calculation of a Thevenin resistance. We have given in Fig. SC2.3a on the left an example of a

simple electrical circuit analogue of a three segment root network with axial and radial resistances ($R_{a,i}$ and $R_{r,i}$). On the right of Fig SC2.3a is shown the corresponding equivalent electrical circuit with a Thevenin resistance. We believe this circuit reflects in general what the reviewer stated. The Thevenin resistance is an effective resistance of the original resistance network. Applying it to a root network in a homogeneously wetted soil, Thevenins resistance (or inversely conductance K_{rs}) can be calculated from the individual root resistances. The transpiration of the entire root system (T_{rs}) can then be calculated as follows:

$$T_{rs} = K_{rs}(\psi_c - \psi_s) \tag{1}$$

where T_{rs} is the total uptake of the root system (m^3/s) at the root collar, K_{rs} (m^2/s) is the Thevenin conductance reflecting the root system (the inverse is the root system resistance), ψ_s (m) is the homogenous soil water potential and ψ_c ($= \psi_x^{(0)}$, m) is the water potential at the root collar. When the soil water potential is homogenous, K_{rs} reflects the total conductance of the root system.

[17] The same concept has been applied in Couvreur et al. (2012), but for root networks in heterogeneously wetted soils, which can be represented similarly (see Fig SC2.3b for the original and equivalent electrical circuits for three segments):

$$T_{rs} = K_{rs}(\psi_{eff} - \psi_c), \tag{2}$$

with

$$\psi_{eff} = \sum (\psi_s^{(i)} \cdot SUF^{(i)}) \tag{3}$$

where ψ_{eff} (m) is an effective water potential, $\psi_s^{(i)}$ (m) is the soil water potential at the element i ($1 \leq i \leq n$), $SUF^{(i)}$ is a dimensionless factor encompassing resistance terms of the root elements. The $SUF^{(i)}$ do also represent the distribution of root water uptake in soils with homogeneous water potential and therefore sum up to one $\sum_{i=1}^{n} SUF^{(i)} = 1$. Notably, Couvreur et al. (2012) showed that even for situations with in-homogenous soil water potential, K_{rs} has the same form as the Thevenin conductance obtained with homogenous conditions. We believe the reviewer probably refers to this concept, when s/he argues that the root resistance does not change depending on the water status around the root. However, it is important to note that in cases where soil water potential is not homogenous along the root, K_{rs} does not reflect the entire root system conductance (or inversely resistance), since the ψ_{eff} also contains resistance terms of the root system (through $SUF^{(i)}$) (see Couvreur et al. 2012 and Appendix 2 of this short comment).

[18] Using the above stated equations in a thought experiment, it becomes obvious that the root resistance changes depending on the soil water distribution, which is the fact where reviewer #1 disagrees with us. For this, we need to take note that in an unbranched root $SUF^{(i)}$ takes smaller values the further away a root element is located from the collar (see Fig SC2.4b, and eqs. 6-8 of the analytical solution in Appendix 2, sect. 1.2).

[19] Consider an un-branchched root of given length, which takes up water from a heterogeneously wetted soil with the flux at the root collar, T_{rs}, being constant in time. Let us compare situation (A) where volumetric soil water content drops from the root collar to the tip with situation (B) where it is precisely mirrored, and increases from collar to tip. This situation is depicted in Fig SC2.4a. K_{rs} is a constant of the root system, $SUF^{(i)}$ is a property of the root segment, which decreases with distance from the collar (see Fig. SC2.4b for $SUF^{(i)}$ in a mature root, 0.5 m length, 100 segments). In both situations the soil contains the same amount of water, and we do not expect differences in soil limitation between situation (A) and (B).

[20] The reviewer states that the root resistance does not change depending on the water distribution around the root (see above). Thus in situations (A) and (B), with the water status being the same (except for its distribution), according to the reviewer root collar potential should be the same. But this is not the case (see in Fig. SC2.4d),

the collar potential is different by 0.58 m. This is because necessarily $\psi_{eff,A} > \psi_{eff,B}$ (different by 0.58 m), due to $SUF^{(i)}$ decreasing with distance from the root collar. As a result, also the xylem potential at the root collar changes between situation (A) and (B) and causes $\psi_{c,A} > \psi_{c,B}$. Thus, the plant total resistance changed, although K_{rs} was the same in situation (A) and (B). This is because (i) K_{rs} only reflects the total plant conductance (inversely resistance) when soil water potential is homogenous along the root and (ii) with heterogenous soil water conditions ψ_{eff} is not a soil property, but a mixture of soil state and resistances of the root network.

[21] This thought experiment shows that the plant resistance does change depending on the distribution of soil water along the root. Those situations are common when root water uptake moves along the root away from the collar.

[22] Now, having discussed the change of resistance along roots of the same length, this does still not settle the dispute about our background section, where we use root resistance of a single element to calculate an optimal root length and motivate axial limitation. The reviewer comments:

> *"Firstly, in a hydraulic architecture seen as a succession of root segments, each having a radial and an axial conductance, adding a root segment (i.e. increasing the total root length) is equivalent to adding a conductance in parallel (even if the root is unbranched). Adding a conductance in parallel in a hydraulic network never provokes a decrease of the overall hydraulic conductance of the network (unless radial conductances would be null). This invalidates the whole background section and the newly introduced idea of axial limitation, which must be considered as very misleading."*

We agree that this is the case in homogeneously wetted soil. We also agree that the background section needs revision, and we thank the reviewer for pointing this out. There is a further clash between the model used in the background section and a root

network: Adding root segments to a root not only adds a conductance element to the analogue electrical circuit, but also increases the water reservoir available to the root. Thus, a longer root has access to more water and will be able to maintain transpiration for a longer period of time. And this is regardless of whether the prolongation is beyond the said “efficient root length” or not. So, how can we state that root resistance increases?

[23] We intended the thought experiment of our background section to be related to the time integral of the water uptake processes, spanning from standard moist conditions up to water limitation, and encompass water uptake moving along the root. In our background section, we force water to be taken up equally along the root. This is a simplification of the real process, assuming that water uptake moves away from the collar and when integrated over time it is (almost) equal along the root. The moving uptake also sequentially increases the active root length, which we incorporate be increasing the length of the single segment. Unfortunately, there is no formulation (we are aware of) to calculate the average resistance of a root network with moving uptake fronts. However, the simple one-segment model has optimal active root length, which we can compare to the real case by way of the average collar potential (effort). For the corresponding root network, we argue, that the further the uptake moves away from the collar, the less water can be taken up per decrease in xylem potential. When calculating the time average xylem potential (in the time constant case) over the said period, it will be least negative at an optimum root length. In other words, further prolongation of the root is not as efficient, as growing a new young root branch.

[24] In the new background section, we will point out that this simple example adheres to the total process of water uptake and not to a instantaneous situation, nor to a instantanous resistance. We will also explain, that this example should illustrate that an efficient root length exists, beyond which growing of a new root is more efficient than prolonging the existent one and that the exact definition of efficiency will be given in the methods section. Further we will explain that the efficient root length is a result

of the axial resistance increasing with the distance water has to travel along the axial path, and that we will call this situation axial limitation.

[25] The term “axial limitation” has also been strongly criticized by the reviewer, who states that our use of it defies established definitions:

> *“They mention that the fact that "the maxi- mum uptake occurs at root ends is counterintuitive (. . .) because the uptake at root tips should suffer from axial limitation", which is the common use of the term axial limitation, but does not correspond to the definition of axial limitation introduced by the authors in their manuscript. The authors should avoid using the same term for two different concepts.”*

The reviewer stated already in “RC C40 Referee comment by anonymous referee #1” , RC 35 that “axial limitation” usually names a situation, where water uptake is reduced at the outer ends of the root due to the longer and thus more resistive axial pathway. We do however not find that the term “axial limitation” is coined for this particular situation. The term “hydraulic isoloation” is chosen by some authors to describe the same thing (examples: Zwieniecki et al., 2003, North and Peterson, 2005). Although we believe the concepts (the one described by the reviewer and the one in our background section) are strongly related, in the new manuscript we will make sure to separate them. We agree that it leads to confusion.

4 Major issue #2: Choice of measures for efficient root water uptake

[26] This was also an issue, which was pointed out by the editor as major. Again, we agree with the reviewer that we need to lay out much more clearly what has been used in the past, what is new and how we modified existing concepts to our specific case.

[27] The reviewer comments that the two measures are related:

> *“The authors also mention that water yield is strongly related to overall transpiration, while effort is more related to whole plants function, which I suppose would make them complementary. They are actually both strongly related to overall transpiration (power in equation A3 also equals the flux exponent 2 divided by root system hydraulic resistance, even though the authors used a different, but equivalent, expression for power). Regarding water yield, in addition to be strongly related to overall transpiration, higher values of water yield must occur for lower root system hydraulic resistance (because of earlier water stress). The fact that both indices are so correlated is thus not a surprise.”*

We agree, that it is not a complete surprise. However, one measure is more intuitive than the other. Yield is intuitive, since it simply refers to the flux over the boundary, and this has been evaluated before to compare model parameterizations (Javaux et al., 2008, Zwieniecki et al. 2003). On the other hand, effort is really a new way for evaluating the plant water status over time. We also see that effort is more sensitive than yield, so we believe it is a better measure. Regardless, we find it useful to have effort accompanied by something more intuitive. As already mentioned, we will change the introduction of the two indices and also mention that they are related, and also modify the discussion accordingly.

[28] The reviewer further comments:

> *In their answer to referee # 1, the authors mention that effort is a "new measure", while water yield is a "previous measure"(of the efficiency of plant water uptake I suppose). I admit I didnt know the latter index (which I think is different from "water productivity "), and didnt notice references to such index in the introduction. However, in the abstract and the section 2.4 of the manuscript, the authors mention that they introduce or define two indices, which suggests that they are both new.*

Here we chose to specifically look at the unstressed transpiration (normalized over root length), and name it an efficiency index, that contains information about whether or not a specific root parametrization leads to early water stress. Therefore, we used the wording "introduce". As mentioned above, we will point out the relation to the former use and include the references.

> *"If the authors like their index (effort) to be strongly related to the scenario, they should not repeatedly state that it is a measure of root system overall resistance, but mention that it depends on both the chosen scenario (daily potential transpiration, daily fluctuations of potential transpiration, initial soil water potential, soil hydraulic properties, etc.) and root system hydraulic resistance. I acknowledge that the choice of an index is also a matter of personal taste, but at least the authors need to be clear about which variables it is sensitive to, which is absolutely not the case in the manuscript."*

[29] We understand that our statement, that the effort informs about the plant resistance is not general, especially when comparing scenarios where mentioned factors change. We will in the revision include a statement regarding the fact that the index effort (as well as water yield) depends in the chosen initial conditions, transpiration scenario, and soil hydraulic properties. However, as stated above, we do not believe that plant resistance is independent of the scenario, either. In our simulations we control for those factors, which have an influence on effort (all the ones mentioned above), and we apply it specifically in a modeling study, where it is possible to control them. Therefore, we find that these influences do not affect the presented results.

5 The functional form of effort

[30] The reviewer noted already in the first response ("RC C40 Referee comment by anonymous referee #1") that the functional form of effort in equation A2 in the discussion paper does not reflect the work of the system in analogy with the electric circuit. The reviewer is right, and we thank for catching this. Our situation is not comparable to the electric analogue, since we are not considering a potential difference (which would be the appropriate equivalent to voltage), but only the potential.

[31] We will therefore remove equations A1 and A2 from the paper and replace them, as described in the next paragraph. The change does not affect the functional form of effort. However, together with the necessary improvements when introducing the efficiency measures, it will hopefully improve the clarity of the manuscript.

[32] Any water potential (ψ_w, m or 9810 J m^{-3}) describes the specific Gibbs free energy of water (Edlefsen and Anderson, 1948, article 62), comparable to the chemical potential. Total changes in Gibbs free energy (ΔG, J) in a system under consideration over a period of time (Δt, s) are therefore

$$\Delta G = \psi_w \cdot V_w, \tag{4}$$

where V_w (m^3) refers to the change of water volume in the system. When the system is closed and the change of energy is caused by a water flow (Q_w, m^3/s) over the boundary of the system, the above equation becomes:

$$\Delta G = \psi_w \cdot Q_w \cdot \Delta t. \tag{5}$$

[33] Applying these equations to the coupled plant-root system in a closed container, where the only water flow out of the system is by root water uptake, we can therefore state that the change in Gibbs free energy of the system from a starting point $t = t_0$ up

to a time,t (s), under consideration is

$$\Delta G = \int_{\tau=t_0}^{t} \psi_c(\tau) \cdot Q(\tau) d\tau \qquad (6)$$

where ψ_c refers to the water potential at the root collar.

[34] As the change of Gibbs free energy to go from state A to state B of a closed system equals the mechanical work to go from A to B (neglecting the work of expansion) (Edlefsen and Anderson, 1948, article 21, 62), ΔG is equivalent to the work required for root water uptake. We can define a normalized measure, w(t) (J m^{-3})), which evaluates average work required per unit of water transpired between t_0 and t:

$$w(t) = \frac{\Delta G}{\int_{\tau=t_0}^{t} Q(\tau) d\tau} = \frac{\int_{\tau=t_0}^{t} \psi_c(\tau) \cdot Q(\tau) d\tau}{\int_{\tau=t_0}^{t} Q(\tau) d\tau}, \qquad (7)$$

[35] The latter equation is part of the long chain equation A3 of the discussion paper, which we will split up. We will erase the parts relating the the electrical circuit. We will distinguish between the general case (w(t), see above) and derive the index effort for the time constant case applied in the manuscript. The latter yields that the the effort index is equivalent to the time average xylem potential which has also units of work per unit volume (i.e. J m^{-3}).

6 Additional points mentioned in "RC C204 Answer from referee to SC C145 #1"

[36] Anonymous referee #1 comments in his answer:

> *"I must underline that already in the manuscript abstract, the authors affirm that "the average uptake depth is not influenced by parameterization", which*

> *is also obviously wrong according to the results displayed in figure 8 of the manuscript."*

This is also a reference to RC45 of the review "RC C40 Referee comment by anonymous referee #1" . We acknowledge that our formulation was too strong. As it can be seen in Fig. 8 of our manuscript, time dependent mean uptake depth equilibrates at the end of the simulations. Furthermore, the time averaged mean uptake depth stated in Table 3 of our manuscript differs only by approx 5 % between the different hydraulic paramterizations. Thus we will differentiate between the momentaneous uptake depth and the overall mean uptake depth in the revised manuscript , and will also change the wording accordingly.

> *"In their results, the authors never verified if the overall resistance increased beyond a root length, for the simple reason that they never calculated the overall root resistance (effort is not the overall root hydraulic resistance)."*

[37] We agree that we insufficiently explained the difference between the terms "overall resistance to root water uptake" and "plants overall hydraulic resistance", which provokes mis-interpretations of our results. Therefore we did not reply to RC26 or RC32 in our "SC C145 Note to referee #1" . We also acknowledge that effort and plant hydraulic resistance are not the same, and we will improve the motivation of effort in the new version of the manuscript.

[38] However, the physical quantity that we are interested in is the energy a plant has to invest on (incremental) root water uptake, and we compare this amount of energy between roots with different root hydraulic properties but under in other respects equal initial and boundary conditions. It is true that in this study we do not separate between the contribution of plant hydraulic resistance, the distribution of soil water potential,

gravity etc. to effort. We will therefore be more careful when discussing the relation between effort and plant resistance in the revised manuscript.

> *"In figure 2 (a) the authors show that for chosen transpiration rate and soil water potential, root collar water potential does not increase with root length, which is the direct confirmation that root overall resistance does not increase with root length (for sufficiently fine root discretizations). Interestingly, in figure 2 (c), the authors show that effort increases with root length (even though root hydraulic resistance does not change)."*

[39] Please note that Fig. 2(a) of our last reply refers to the specific case of a homogeneous soil water potential. The effort depicted in Figure 2(c) integrates over the entire transpiration period in which soil water potential is heterogeneous, and resistance changes depending on the soil water potential distribution (see above). The latter is responsible for the existence of a minimal effort.

> *"It would thus take more time to reach the critical collar water potential. In case the plant with longer root spends this additional time at collar potentials that are relatively close to the critical collar potential, its effort might be higher than the effort of the plant with shorter root. In other words, even though the collar water potential of the plant with long root is always lower than the collar potential of the one with short root, its effort might eventually be higher. This would contradict another statement of the authors about effort : "lower effort is tantamount for lower xylem water potentials over the course of time". In the case of water yield, it should be even clearer that the longer root does not stress before the shorter root. The water yield of the long root should thus always be higher."*

[40] It is true that unstressed transpiration lasts longer for longer roots. This is why we applied a normalization for both indices (see discussion paper): Yield is normalized by

root length, and effort is normalized by total transpiration until the evaluation time (i.e. see eq. (7) of this short comment or A3 in the discussion paper).

[41] Due to the normalization, water yield is not always higher in longer roots. Furthermore, Fig. SC2.5a shows the time evolution of xylem potential of the scenario the reviewer liked to see. The optimal root length for the mature root strand is 1.80 m (solid line). The time average of the xylem water potential is more negative (a greater effort is necessary on average) in the longer than optimal root. This is because unstressed transpiration lasts longer, and is in agreement with the reviewer. Clearly, increasing the root length is an advantage, but it can be done either by prolonging an existing root or by growing a new root. This is shown in Fig SC2.5b. When exploring the same soil water reservoir with multiple shorter roots, it can be depleted at less negative average xylem potentials (smaller effort). This is an important point and we will include a discussion of this (maybe with a similar plot) in the revised manuscript.

[42] We have tried to address all points the reviewer raised in "RC C204 Answer from referee to SC C145 #1" . We appreciate the time spent by the reviewer to discuss our manuscript. We believe in several points we have reached agreement with the reviewer and will use those insights to improve the manuscript.

[43] We also understand that some disagreement between ourselves and the reviewer pertains. We have made an effort to understand the sources of disagreement and conducted additional analyses to substantiate our argumentation. We will respond to the remaining issues from "RC C40 Referee comment by anonymous referee #1" in a point by point response, which we will prepare together with our revised manuscript. At the end, we would also like to mention that we found the words used by the reviewer partly disparaging ("what the authors write (. . .) is a pure nonsense ") and would really appreciate a collegial tone.

Thank you again.

7 References

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Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/11/C549/2014/hessd-11-C549-2014-supplement.pdf

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