

Hydrol. Earth Syst. Sci. Discuss., author comment AC2  
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## Response to RC2

Aaron J. Neill et al.

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Author comment on "Structural changes to forests during regeneration affect water flux partitioning, water ages and hydrological connectivity: Insights from tracer-aided ecohydrological modelling" by Aaron J. Neill et al., Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2021-158-AC2>, 2021

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### HESS\_2021\_158: Author responses to RC-2

#### Summary

The manuscript by Neill et al. presents an ecohydrological modelling study about structural changes of forest regeneration and the effect on water flux partitioning, water ages and hydrological connectivity. They use the ECH<sub>2</sub>O-iso for a small experimental catchment in the Scottish Highlands and simulate a baseline and two land cover change scenarios, a thicket and an old-open forest.

The modelling study gives the opportunity to create an old-open forest which might be very difficult to create in a field experiment due to long time period over 100 years, and agriculture forest use (tree age around 40 years). This stage of old forest might happen if the forest harvesting stops, hence especially for stakeholders it is interesting to see the influence of such forest development. But also, the research community gets an idea about the effects of a thicket and an old-open forest to the hydrological conditions. This could help to see the field experiments with a different angle and to support information around such experimental sides.

The text is well structured with meaningful subheadings and well-structured paragraphs. The manuscript is in the scope of the HESS journal and gives new insights in the field of tracer-aided ecohydrological modeling.

I see an especially need to strengthen the text for an easier readability with less abbreviations and clear sentences. The figures and table also need some revisions for an easier readability, e.g. bigger fonts. Here I give some general comments and specific comments at the end. ("Line" is abbreviated with "L").

*Response to Summary: We appreciate the careful review and positive comments. We are also grateful for the many constructive suggestions provided by the reviewer, although note that in a lot of cases these relate to very minor details of the manuscript and its presentation. We therefore hope the reviewer can appreciate that we do not always find the need to accommodate all their suggestions. Please find our individual responses below.*

## General comments

Abbreviations:

RC-2.1: I suggest to reduce the abbreviations for easier and an undisturbed readability. Especially since some abbreviations are just used a few times (e.g. SW 4x, VWC – 6x, RZ – 7x, OLF-13x). From my point of view, I would only keep LAI and use the full words for the others. ET and GW, might be an option to keep as well, but it still interrupts the reading (as an alternative, a table with all the abbreviations could also work).

*Response to RC-2.1: We will use the full words for abbreviations that appear fewer than 10 times to improve readability. Respectfully, however, we believe the use of abbreviations occurring more frequently is justified given the manuscript length, as is use of the common abbreviations ET and GW.*

RC-2.2: Some abbreviations are not introduced in the text e.g. NE (Line 286), SE (Line 463), NW (Tab1, L 385, L403)

*Response to RC-2.2: As these refer to commonly used ordinal directions, we did not see the need to define. However, to improve readability these directions will be written out in full.*

RC-2.3: Leaf area index is mentioned in L 93, but introduced in L 186, I would also suggest not to introduce the LAI in italic, or if this is really necessary only use the italic version, also for figures and tables

*Response to RC-2.3: LAI will be introduced in L93 instead. When LAI is in italics, it indicates that it is the model parameter being referred to; however, we now see that this is not necessarily obvious and will clarify in L186.*

RC-2.4: Bruntland Burn, I would suggest to keep the whole name instead of just BB

*Response to RC-2.4: Respectfully, we would choose to keep the abbreviation BB when referring to the catchment as this has been common practice in previous papers based at this site.*

Figures:

RC-2.5: In general, the figure captions are quite short, maybe some more information for the reader to understand the meaning of each figure can be added.

*Response to RC-2.5: Thank you for this comment, we will add more information as appropriate when responding to the specific comments for each Figure.*

Fig. 1:

RC-2.6: The symbols should be the same for the same type of station e.g. gauging station in the river (one symbol), weather station (another symbol), ect.

*Response to RC-2.6: We will update the symbols in Figure 1a accordingly.*

RC-2.7: DW abbreviations should be explained (unclear for me what it could be)

*Response to RC-2.7: DW refers to deeper groundwater well. This will be defined in the figure caption.*

RC-2.8: Map in the left corner is too small, better to use a bigger map with some parts of Europe to show persons from everywhere, where the catchment is located

*Response to RC-2.8: We will make the context map of Scotland bigger. Respectively, however, we disagree that a more expansive map including Europe is necessary as this will likely make it more difficult to see exactly where in Scotland the catchment is located.*

RC-2.9: The whole figure looks a bit unstructured and a bit chaotic, maybe it is better to split in two figures

*Response to RC-2.9: Following the reviewer's later suggestion, we will move c-g) to Figure 2.*

RC-2.10: 1g) Bog pine, it seems that there is no bog pine at all, is that right? Order the scaling of the vegetation fraction to undifferentiated

*Response to RC-2.10: No, this is not correct. There are some cells with a small cover of bog pine, typically less than 10%. To improve clarity, we will replot c-g) so that 0% cover does not show.*

RC-2.11: The font size of "Vegetation fraction" including number is too small, also the legend of h)

*Response to RC-2.11: We will increase the font size.*

RC-2.12: The font size of the headings of c) to g) could be little bit bigger

*Response to RC-2.12: We will increase the font size if possible when incorporating c-g) in Figure 2.*

RC-2.13: In Tab 2, Groundwater wells are mentioned. Maybe you can also include the location in this figure

*Response to RC-2.13: As noted above, groundwater wells are denoted by DW1-4 and will be defined as such in the figure caption.*

Fig. 2:

RC-2.14: What is "Regen-baseline", better (regeneration – baseline scenario), since there is enough space to write the full text

*Response to RC-2.14: This will be written out in full.*

RC-2.15: Maybe it is an option to include Fig 1 c) to g) in Fig 2, to reduce the overloaded Fig 1.

*Response to RC-2.15: Thanks for this suggestion, we will move Fig. 1 c-g) to Fig. 2.*

Fig. 3:

RC-2.16: Please add a legend to every subfigure, starting with first observation, second spread, or the other way around.

*Response to RC-2.16: Legends will be added to all sub-figures.*

RC-2.17: b) (In  $m^3 s^{-1}$ ), guess it is just ( $m^3 s^{-1}$ )

*Response to RC-2.17: No, this is not correct – Ln denotes that it is the natural logarithm of discharge that is plotted, which improves visibility of lower flows. This will be clarified in the figure caption.*

RC-2.18: Font size could be a bit bigger, for easier readability

*Response to RC-2.18: Unfortunately, font sizes have already been optimised for this figure given the large amount of data to present and, therefore, cannot be made bigger.*

RC-2.19: For the caption I would suggest: a) Precipitation; b) and of observed and simulated Discharge; c) [...]

*Response to RC-2.19: Respectfully, we opt to leave the caption as it is since "observed and simulated" relate to all subsequent variables after precipitation, not just discharge.*

Fig. 5:

RC-2.20: Discharge again (In  $\text{m}^3 \text{ s}^{-1}$ )

*Response to RC-2.20: Again, this is correct and will be clarified in the figure caption.*

RC-2.21: What is the brown color? The red on top of green? This is hard to see, even for a non-color-blind person (maybe you can find other colors e.g. red and green is not visible for many persons)

*Response to RC-2.21: Thank you for this comment. The brown colour is where simulations for the thicket and old-open forest overlap. We will change the colour scheme to be colour-blind friendly and make a note in the figure caption in relation to the colour of overlapping simulations.*

RC-2.22: Caption maybe: c) Stream water ...

*Response to RC-2.22: This will be incorporated.*

Fig. 6:

RC-2.23: "Baseline:" It is better mentioned it in the Figure caption, but not as a heading, if it is always the same for all cases.

RC-2.24: I would also suggest to write groundwater instead of GW and evapotranspiration instead of ET, since it is enough space to write the full word.

RC-2.25: Font size should be a bit bigger, for easier readability

*Response to RC-2.23 to RC-2-25: Respectfully, we do not see the need to adopt these changes as they are very minor relative to the effort needed for incorporation (especially regarding increasing font sizes given the large size of the figure already).*

RC-2.26: For comparison, it would be much easier to read and compare the subfigures, if the "spread"- median daily average would always be the same size. e.g. from 0 to 30 or so for the blue ones and 0 to 2.5 for the green ones.

*Response to RC-2.26: Whilst we understand the reviewer's point here, we are keen to use separate scales for each set of fluxes so that the spatial patterns and differences between seasons for each flux can be clearly identified.*

RC-2.27: What are the brown pixels in a) and e), please explain e.g. in the figure caption

*Response to RC-2.27:  $\text{Ech}_2\text{O}$ -iso does not simulate overland flow for cells containing a stream channel nor groundwater outflow for outlet cells. Consequently, there is no value of overland flow or groundwater outflow to show for these cells, so the brown base map is*

*visible. This will be explained in the figure caption.*

RC-2.28: Caption: please define the abbreviation "L1"

*Response to RC-2.28: This will be replaced with "soil layer 1".*

Fig. 7:

RC-2.29: What are the brown pixels in a) and e), please explain e.g. in the figure caption

*Response to RC-2.29: ECH<sub>2</sub>O-iso does not simulate overland flow for cells containing a stream channel nor groundwater outflow for outlet cells. Consequently, there is no value of overland flow or groundwater outflow to show for these cells, so the brown base map is visible. This will be explained in the figure caption.*

RC-2.30: To get an easier overview I would suggest to write the month in the middle over the first and second subfigure column, and the third and fourth subfigure column, since they are always showing the same time frame, just the scenarios are different.

*Response to RC-2.30: Respectfully, we do not feel the effort needed for such a minor change is warranted.*

RC-2.31: Again, please use the same spread for all figures maybe 0.5 to -9

*Response to RC-2.31: Whilst we understand the reviewer's point here, we are keen to use separate scales for each set of fluxes so that spatial patterns in the differences of each flux can be clearly identified.*

RC-2.32: Caption: e) GW flow instead of Groundwater flow

*Response to RC-2.32: This will be changed.*

Fig. 8:

RC-2.33: Again, please use the same spread for all figures maybe +1 to -1

*Response to RC-2.33: Whilst we understand the reviewer's point here, we are keen to use separate scales for each set of fluxes so that spatial patterns in the differences of each flux can be clearly identified.*

RC-2.34: Again, I would suggest to write the month in the middle over the first and second subfigure column, and the third and fourth subfigure column.

RC-2.35: Font size should be a bit bigger, for easier readability

*Response to RC-2.34 and RC-2.35: Respectfully, we do not feel the effort needed for such minor changes is warranted.*

Fig 9:

RC-2.36: For an easier overview you might consider to include the timing, so 22 July 2013, 10 August 2014 and 30 December 2015 or dry summer period, summer wet period and 100-year return period flood, or something like this

*Response to RC-2.36: Thank you for this suggestion, we will add the event dates to the figure itself.*

RC-2.37: The figure caption does not fit on the same page, so the figure must be small, but it is no option to just minimize the total figure, since already now the text and numbers are very hard to read

*Response to RC-2.37: To condense this figure, we will remove the histograms. Then, instead of plotting the proportion of behavioural runs a cell is connected on the maps, we will plot cells that are connected in at least 50% of behavioural runs and colour them by their flow path lengths. This will allow the figure to convey very similar information but in less space, whilst also allowing modifications to the figure as detailed in the responses to Reviewer 1.*

Tables:

RC-2.38: In general, the table captions are quite short, maybe some more information for the reader to understand the meaning of each figure can be added.

*Response to RC-2.38: Thank you for this comment, we will add more information as appropriate when responding to the specific comments for each Table.*

Tab 1:

RC-2.39: The whole "cover" column should be left-justified, or why is only "As baseline" right-justified?

*Response to RC-2.39: "As baseline" is not right justified within the Cover column but instead extends across the Cover, Height and LAI Scale Factor columns as these factors are unchanged in the regeneration scenarios for the relevant vegetation types.*

RC-2.40: Instead of just "cover" maybe "proportional aerial coverage" or something like this

*Response to RC-2.40: This will be updated in revision.*

RC-2.41: The use of italic is confusing, maybe use bold instead of italic for "Baseline", "Thicket woodland", ...

*Response to RC-2.41: Underlining will be used in place of italics.*

RC-2.42: Notes a): "pre-existing" with small letter

*Response to RC-2.42: This will be corrected.*

Tab 2:

RC-2.43: What does "Full" stand for? Full time period? Then maybe also mention again how long this study period is or from x to x.

*Response to RC-2.43: Full stands for full study period – we will indicate this for clarity.*

RC-2.44: I would suggest to only use "and" or "&", not both in the same table

*Response to RC-2.44: We will update the Table to ensure consistency.*

RC-2.45: You might want to explain the A and B behind Forest and Heather

*Response to RC-2.45: A and B refer to north- and south-facing sites, respectively; however, we would argue that in the context of this paper, it is sufficient that A and B simply denote different sites.*

RC-2.46: Where is the location of "deeper well" 1 to 4, maybe include in Fig 1.

*Response to RC-2.46: Please see responses to RC-2.3.*

Tab 3:

RC-2.47: Is it really necessary to give the decimal place, full numbers are easier readable (like done in Tab 4)

*Response to RC-2.47: We will update the table so that only full numbers are presented.*

RC-2.48: What is the added valued to include the second columns with the differences in seasonally averaged flux totals □ The table is quite confusing, so maybe it is better shorten the given information, if possible (this also applies for Tab 4)



*Response to RC-2.48: The added value of showing the differences in seasonally averaged flux totals is that they more clearly indicate whether the simulated direction of change was consistent amongst behavioural models. This may not be obvious from considering summaries of the seasonally averaged flux totals themselves.*

Words:

RC-2.49: Please stick to one version of "old-open" or "old open" including the abstract, tables and figures

*Response to RC-2.49: This will be checked for consistency in revision.*

RC-2.50: Instead of Oct-Mar and May-Sep I would introduce the words of summer and winter or, dormant season and biological active season, beside a better readability this might also be an improvement of the figures, if you want to stick to the month, I would suggest to write the full names like October to March.

*Response to RC-2.50: We will introduce Oct-Mar and Apr-Sep as the dormant and biologically active seasons, respectively, and make appropriate changes throughout the manuscript.*

Introduction:

RC-2.51: L 95 – 99 You explain, that the soil properties are held constant, but then further describe that they might change. I guess, it would be very interesting to see the effect of soil property changes. How strong is the effect here?

*Response to RC-2.51: Here, we sought to justify our choice to keep soil properties constant by arguing that changing them may increase uncertainty in model outputs because a) it is not known how any physical changes to soil properties would be expressed in changes to effective model parameters, and b) it is unclear if/how soil properties might change under coniferous forest because there may be processes operating that counteract one another. Consequently, whilst it is desirable to account for changes in soil properties when modelling land cover change, more research is likely needed regarding how exactly properties change under different land cover types and how these changes translate into modifications of effective model parameters. This is indicated in Section 6 (page 30 L591-595).*

RC-2.52: Also, climate change has an important impact to the soil and plants, especially in a 100-year scenario. Maybe you can further explore this part in the introduction or later on.

*Response to RC-2.52: Thank you for this comment. To also address comments from Reviewer 1, we will add a short section at the end of the Discussion to comment on possible uncertainty in the modelled scenarios due to factors such as climate change.*

### 3.1 The Ech2O-iso model:

RC-2.53: The model description part with its concept is a bit imprecise.

*Response to RC-2.53: We apologise but it is not clear from this comment what exactly the reviewer would like us to change. In revision we will ensure that the description of Ech<sub>2</sub>O-iso is as clear as possible.*

RC-2.54: The kinematic wave model in the groundwater context (L.154 -160) is not so common, it is normally known for open channel routing. Maybe you can explain this point a bit more detailed. From the description, the term GW is maybe not the right one in L 157, maybe it is interflow? Is there an exchange of river and groundwater (in one or both directions)?

*Response to RC-2.54: We will further explain the GW routing mechanism. In Ech<sub>2</sub>O-iso, only water in excess of field capacity in layer 3 can move laterally in the sub-surface. This water is conceptualised as GW and therefore this is the appropriate term in L157. There is a one-way exchange between the stream and GW whereby the latter can seep into the former (L159); we will briefly expand on the details of this interaction.*

#### Calibration:

RC-2.55: Give less references to the specific parts of the figures and table. e.g. L339 to 342 (Tab 3) at the end of the sentence is enough. There are many other places where the references to Tables and Figures can be reduced for a much easier readability, without losing information. (e.g. L345, L 346, L 355 (when the whole paragraph is about the figure introduces at the beginning it is not necessary to refer to all the subfigures after each sentence.)

*Response to RC-2.55: In revision we will ensure that references to figures and tables are appropriately succinct.*

RC-2.56: 4.1 Baseline calibration: refer more to the Table 2, e.g. with the MAE for discharge.

*Response to RC-2.56: OK.*

#### Discussion:

RC-2.57: Sometimes difficult to read, especially the very long sentences: L 480 – 483, L 491 – 494, L 507 – 510, L 542 – 545, L 560 – 563

*Response to RC-2.57: In revising the manuscript we will endeavour to reduce the length of overly long sentences throughout.*

RC-2.58: Here you introduce the terms of dormant season and biological active season

(L490 – 491), and winter and summer (e.g. L 505), but without giving the month you refer to in you catchment.

*Response to RC-2.58: We will introduce Oct-Mar and Apr-Sep as the dormant and biologically active seasons, respectively, and make appropriate changes throughout the manuscript.*

Specific comments:

RC-2.59: L 39 – 42: very long sentence, please split in two

*Response to RC-2.59: This will be changed.*

RC-2.60: L 82: maybe delete "which"

*Response to RC-2.60: "Which" is necessary here.*

RC-2.61: L90: maybe give the catchment area in brackets, and not only call it small

*Response to RC-2.61: Respectively, we do not think it necessary to quote the size of the catchment here since it is introduced shortly after in Section 2.*

RC-2.62: L94 – 99: changes in soil properties are not included in the model, but here explained that it is very likely to happen. Why are you not including soil property changes when you think they are happening and important? I guess it needs more thoughts why you did not include them. Also, a connection from the missing soil property changes to the specific objectives of the manuscript would be helpful.

*Response to RC-2.62: Please see Response to RC-2.52.*

RC-2.63: L 106: reference to Fig 1, not only Fig 1a, the whole figure gives information about the catchment

*Response to RC-2.63: OK.*

RC-2.64: L 116: (SNH, 2016) instead of [SNH, 2016]

*Response to RC-2.64: This will be changed.*

RC-2.65: L 123: Maybe better: Mean annual precipitation is 1000 mm and potential evapotranspiration is 400 mm, with the [...]

*Response to RC-2.65: This will be changed as suggested.*

RC-2.66: L 125: Maybe better: [...] mean temperatures ranging between 1 °C in winter and 13 °C in summer.

*Response to RC-2.66: This will be changed as suggested.*

RC-2.67: L 128: please include catchment after BB, also in the other cases in the manuscript so "... BB catchment" e.g. L 197, L 210, ...

*Response to RC-2.67: This will be incorporated in revision.*

RC-2.68: L 149: please explain the soil layer L1, L2 and L3. Is the L1 the top most? How are they defined, maybe with the soil horizons? Or just with a given depth?

*Response to RC-2.68: L1 is the top-most layer. The depth of each layer is typically a free parameter requiring calibration (the case in this application). This will be indicated within the description of Ech<sub>2</sub>O-iso.*

RC-2.69: L 155: please give the source of the Green-Ampt model

*Response to RC-2.69: Mein and Larson (1973) will be given as the appropriate reference for the implementation of the Green-Ampt model in Ech<sub>2</sub>O-iso.*

RC-2.70:L 168: what is meant by "spatially uniform", please describe further

*Response to RC-2.70: By this we meant that the properties of each soil type are uniform in space. We will update to: "The properties of each soil type were assumed to be spatially uniform".*

RC-2.71: L 182: better: 100 m x 100 m grid

*Response: to RC-2.71 This will be changed as suggested.*

RC-2.72: L 183: add "in the supplementary Table S1." Or something similar, to know where to find the table, since it is not in the manuscript itself. Also, at other places when referring to the supplementary material e.g. L 185, L 190, L221, ...

*Response to RC-2.72: References to supplementary material will be clarified throughout the manuscript.*

RC-2.73: L 188: What kind of channel? River channel?

*Response to RC-2.73: Yes, for the river channel – this will be clarified.*

RC-2.74: L 207: "to avoid over-emphasising high flows" – compared to what? Compared to NSE?

*Response to RC-2.74: Yes, this is compared to metrics based on mean squared errors, such as NSE. This will be clarified.*

RC-2.75: L 271: add ... periods of biological growth and dormancy in our study area. Or something similar

*Response to RC-2.75: We will introduce Oct-Mar and Apr-Sep as the dormant and biologically active seasons, respectively, and make appropriate changes throughout the manuscript.*

RC-2.76: L 289: model skills instead of model skill

*Response to RC-2.76: Skill should be singular here, but we will rewrite "model skill" as "skill of the model" for clarity.*

RC-2.77: L 291: Tables 2 and S2, since the supplementary, should just give additional more detail information, so is less important and should be mentioned as a second.

*Response to RC-2.77: This will be changed as suggested.*

RC-2.78: L 369: "zero" instead of "0"

*Response to RC-2.78: This will be changed as suggested.*

.....

New references not currently in manuscript

Mein, R. G., & Larson, C. L. (1973). Modeling infiltration during a steady rain. *Water Resources Research* 9(2): 384–394.