hess-2021-158 review

The authors present a modelling study analysing the effect of forest regeneration on blue and green water fluxes for a catchment in the Scottish Highlands, which have undergone dramatic decreases of native pinewoods since the 17th century. The authors use the tracer-aided ecohydrological model EcH2O-iso (Kuppel et al., 2018a) to model flux partitioning, water ages and hydrological connectivity under three different conditions (i.e., baseline conditions, thicket forest and old-open forest) representing different stages of natural forest regeneration.

The model results highlight that the thicket forest stage leads to the greatest changes in flux partitioning, water ages and hydrological connectivity especially during low flow, while establishment of old-open forest will likely result in the system returning to similar ecohydrological fluxes as during baseline conditions.

The authors argue that this study demonstrates the importance of considering different stages of regeneration as well as their spatial and temporal impact on ecohydrological partitioning to accurately inform landscape restoration.

General comments

The study fits the scope of Hydrology and Earth System Sciences and represents an important contribution to investigating the effect of landscape restoration. The study uses existing concepts and methods, but applies them to different landscape scenarios than previous research. Hence, the paper represents a substantial contribution to scientific progress in this field.

The paper is well-written and considers an appropriate amount of related work. The figures and tables are well chosen to support the results and conclusions of the study.

I do not have major general comments, but I am missing some more in-depth discussion as to (1) the added value of the isotope module and (2) the likelihood of the two land-cover change scenarios under climate change. For (1), the authors refer to the validation by Kuppel et al. (2018a), but it would be useful to discuss in the paper to what extent the isotope data helped constrain model parameters and whether the model parameters sensitive to the isotope data are crucial for this study. In view of the uncertainty bounds in the behavioural solutions and to illustrate the value of the isotope data, the authors might want to include a baseline simulation without isotope data and compare the model uncertainties to those of the tracer-aided simulation. Related to this is also the discussion of changes in water ages with progressing regeneration (section 5.2), which should underline more why this information is highly beneficial for assessing regeneration changes as opposed to looking at the changes in blue and green fluxes only (and thus why we need the isotope data).

Regarding (2), given that the full regeneration to old-open forest might take several decades, I am wondering whether changing climate might lead to a different trajectory of change than the one depicted in the study. More specifically, how realistic is it that the system can meet increased evaporative demand during summer (e.g., Werritty and Sugden, 2013)? Would it be possible to test this for the study catchment with the EcH2O-iso model (see page 30, lines 595–599)?

I also have a comment on the data availability. According to the HESS data policy, “data and other information underpinning the research findings are "findable, accessible, interoperable, and reusable" (FAIR) not only for humans but also for machines”. If the data cannot be made publicly available, there should be “a detailed explanation of why this is the case”. Please provide the data in an open repository or explain why this would not be possible.

Specific comments

- page 6, line 150: do you mean that there is an exponential decrease of roots in each layer with depth? Please clarify.
- page 6, line 160: could you briefly comment on the impact of this assumption of complete mixing? With a total soil depth of around 30 m in some simulations, how does this assumption affect the water age simulation? I could imagine that the L3 soil layer might contain a relevant proportion of older water, which might bias the water age of transpiration towards older ages using the complete mixing assumption.
- page 6, line 168: “soil types were assumed to be spatially uniform”. I am not sure I understand. Do you mean there is only one soil type per cell (as in Fig. 1a) or what exactly is spatially uniform? Also it is not clear to me how to read Table 1: should the percentages across all vegetation types (including bare soil) for each soil type add up to 100%? Could you explain this in a bit more detail in this paragraph?
- page 9, line 214: how many simulations meet the criterion of simulated saturation areas < 60%? Why are only 30 runs of those retained as behavioural results? This is probably a small proportion of the first subset, but it still gives large uncertainty bounds, for example, in flux ages.
- page 12, lines 282–283: I do not fully understand. What kind of threshold and what is the role of reinfiltration along a flow path? Please clarify.
- page 13, lines 290–291: could you also state the values of the performance metrics for behavioural runs?
- page 27, lines 507–510: “Greater consistency…”. I am not sure I understand. Do you mean that regeneration does not affect the fluxes during larger events because of sufficient amount of rainfall and stored pre-event water during these events?
- page 28, lines 517–520: So would that mean that the old forest state might be achieved much later or maybe not at all?
- page 29, lines 554–555: I do not see big differences in the connectivity changes between low / moderate summer events and the large winter event. Could you support this assertion by mentioning percentage changes in section 4.7?
- section 5.3: see general comment (2): I would appreciate some words on the likelihood that regeneration would undergo these two forest stages in view of climate change. Could it be that less rainfall/higher ET in summer would lead to a diversion of pinewood regeneration as depicted in Fig. S1 such that increased transpiration demand of thicket forest could not be met and transition to old forest would not occur? This links to the statement on exploring trajectories of change made in the Conclusions.
- page 30, line 590: see general comment (1): I am not sure about the benefits of the isotope observations here. Do we need the isotope module of the model or what additional validation data might be useful to constrain the uncertainty bounds? Could the authors comment on the uncertainty that would result from calibration without isotope data? Is it the comparably low temporal and spatial resolution of soil-water isotope data that limits the uncertainty reduction?

Technical corrections

- page 5, line 142: grid<u>d</u>ed

Tables

- Table 1: how did the authors determine the exact proportional aerial coverage in the two scenarios? References are given here but it is not clear to me whether/how these numbers have been derived from the information provided in the references

Figures

- Figure 1a: would it make sense to have more meaningful symbols and/or colours for the monitoring sites, grouping weather stations, soil types and vegetation?
- Figure 1: could you also include a digital elevation model so it is easier to see the location of the hillslopes in the catchment?
- Figure 9: could you also show the dates of the different snap shots directly in the figure? If not, the reader has to switch back and forth between the figure panels and the figure caption.

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References used in this review

Kuppel, S., Tetzlaff, D., Maneta, M.P., Soulsby, C. (2018a). EcH2O-iso 1.0: water isotopes and age tracking in a process-based, distributed ecohydrological model. Geoscientific Model Development 11: 3045-3069. DOI: 10.5194/gmd-11-3045-2018

Werritty, A., & Sugden, D. (2012). Climate change and Scotland: Recent trends and impacts. *Earth and Environmental Science Transactions of the Royal Society of Edinburgh, 103*(2), 133-147. doi:10.1017/S1755691013000030