

Interactive comment on “Assessing the influence of soil freeze-thaw cycles on catchment water storage – flux – age interactions using a tracer-aided ecohydrological model” by Aaron A. Smith et al.

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In this paper, the authors apply a tracer aided hydroecological model to assess the role of frozen ground on water fluxes, storage and ages in a cold regions watershed in northern Sweden. The model performed well enough to make sound conclusions about the relative magnitude of fluxes and the distribution of ages of water comprising different components of the water budget. The subject matter of this research is very relevant in regards to beginning to address larger questions about how climate, vegetation and hydrology interact. These are important questions as the globe warms,

and tools such as the model introduced here will be important for predicting and attributing change. The paper is well written. I have some minor suggestions where improvements could be made. A bigger concern is an incomplete explanation of how the authors assessed the role of ground frost on water fluxes and ages. The authors explain that they turn frost dynamics off in the model to do so. I perhaps misunderstand, but how is it possible to not have the soil freeze if the same forcing dataset is used? This is a crucial piece in the methodology and it needs better explaining than currently exists. Without it, the paper does not achieve its goals.

There are some suggestions I have that might improve the presentation. My specific comments are below.

Page 1 Line 34: It is not clear how the limited number of monitoring sites is tied to implications of hydrological change. Maybe rephrase to “The limited number of long-term monitoring sites with high quality data is a concern because it may prove difficult to document the anticipated hydrological change in these catchments”.

Page 4 Line 39: How is the equation presented here related to the assumption that the ground and snowpack temperature are the same?

Page 5 Line 50: Here and elsewhere, the paper would benefit greatly from the inclusion of units when introducing variables. Page 5 Line 50: These equations imply the soil moisture scheme assumes no movement of water in the column? I cannot think this is correct, and I must misunderstand. Could the authors please improve the clarity here?

Equation 6: It might be the version I see, but the equation seems incomplete and the description doesn't quite match with no mention of outflow.

Page 5 Line 62: Perhaps show the equation from Ala-aho, to show the difference to the reader.

Figure 1 could be better drafted and explicitly label the locations of S12 and S22.

Page 6 Line 90: Not all of this section includes model data, and some is observational

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data. You could perhaps retitle the section “Observations”.

Page 7 Line 20: Perhaps put the simulation period right at the beginning of the section.

Figure 2: Could the authors add a sentence or two explaining why the water ages bottom out every now and then? Perhaps I have missed it.

Page 10 Line 89: Are the words dynamic and damped mixed up?

Figure 3: Please explain what ‘normalized’ means.

Figure 3: Also, why does the soil water age get younger as the summer progress? The paper would benefit from a few sentences explaining this behaviour.

Figure 5: Just so apples are compared to apples, perhaps total modelled evaporation and transpiration so that it can be more easily compared to the ICOS data.

Page 13 Line 41: A citation might be useful here because the data from this paper do not support such a statement.

Page 15 Line 88: The authors have access to soil temperature data that could show if this is underestimated. A figure might help address this gap. Also, please explain how the assumption of no temperature gradient through the snowpack influence these results.

Page 15 Line 93 – 99: There are some typos through this section that could be fixed.

Page 16 Line 27: I missed where the ages of the soil frost are provided. It would be valuable to show them.

Page 16 Line 30: It would be helpful to provide data on the relative values of these fluxes and storages in the text here to let the reader know how important each is to determining the age of water.

Page 16 Line 32: Maybe rephrase to “...of older soil frost with younger soil water and snowmelt reduces....”

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Page 16 Line 35: Was it limited or just hard to detect within the uncertainties of the model? This is an important point of discussion that is missing.

Page 16 Line 43: I am not convinced the results of the research support these statements. Please clarify. If more water is pulled from soil subject to warming would not that speed up the pattern observed in Figure 3? And in turn reduce age?

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