

Response to Reviewer 2 comments

We thank the Reviewer 2 for thorough comments and naturally share his/her opinion that the study provides important contribution and was worth doing. Relatively minor changes to manuscript structure are in our opinion sufficient to significantly improve clarity and address the important points raised by the reviewer. The main criticism was directed to some specific sections in the manuscript, where the structure and clarity could be significantly improved. In this respect we have received two somewhat conflicting reviews and ask Editor Opinion on whether further changes are necessary.

Specific comments (C) and our responses (R)

C: It seems the authors have a chaotic design for the m/s, for example when Fig 3 is talked about in page 12 the authors suddenly refers to Fig 10, and then jump back to Fig 4

R: Referring Fig10 here was a mistake; should have been lowest panel of Fig3 (labels e, f added to new version).

C: Page 4 Line 25 and 28: in the two equations, two symbols for the same leaf area index are used.

R: The leaf-area index (a stand-level property) is throughout the manuscript referred as LAI (m²m⁻²); the L (m²m⁻²) in the inline equation at P4L25 describes cumulative leaf-area index starting from the canopy top as clearly described in the manuscript. The relation of these variables is thus $LAI = \int_{hc}^0 L(z)dz$, where integration with depth z is from canopy top (z=hc) to ground (z=0).

C: Page 5 in the eq.6, describe how the threshold parameter is determined, based on measurements or calibrated?

R: As stated at P5L13-14 the soil moisture response and threshold parameter value was adopted from Lagergren and Lindroth (2001) sap-flow study. This part will be clarified in revised version.

C: Line 20: since fs is an important stress function in eq.4,it would be better to explicitly write it out, otherwise the readers have to find it by themselves in the literature cited. Note also the math express: at some places you used the form of $y = \exp(x)$, while at others you used $y = e^x$. Be consistent.

R: Same addition was asked by Reviewer 1 and now added in the current manuscript.

C: Page 7: symbol beta is used in both eq.16 and eq.19, but with different meanings.

R: Thanks for pointing this out; term $\tan \beta$ in eq. 19 is now replaced with $\tan \alpha$.

C: Page 9 Line 8-10: delete – it is a repetition of page 8 Line 18-20. Also write in the 2.6.2 section clearly what a larger mu and sigma infer, otherwise when it comes to Results 3.1 and the relevant table, it is hard to comprehend.

R: Explanations what large mu and sigma intuitively mean are added and improve the clarity. We do not see overlap / repetition between P9L8-9 and P8L18-20

C: Page 11: The section 2.6 is 'Model validation at stand and catchment scales', but 2.6.3 is GIS preprocessing, and 2.6.4 is calibrating Topmodel. I don't think they are appropriately positioned. 2.6.3 is better fitted in Model input section, and 2.6.4 merged with parameter sensitivity section.

R: The model is tested/validated both at stand and catchment scales, and further sensitivity analysis is done at stand-scale (section 2.5.). To further improve the logic, we change the structure to be:

2.6 Model validation at stand scale; this includes the former section 2.6.1

2.7 Model validation at catchment scale; this includes the former section 2.6.2 and following sub-sections:

2.7.1 Processing of GIS-data

2.7.2 Calibration of Topmodel against specific discharge

We see this structure most logical for the manuscript content. The Model inputs –section (2.4) describe model inputs in general, and required for both spatial scales; Parameterization and sensitivity analysis (done at stand scale) is described in detail in 2.5, while the two validation scales are now in separate sections. We don't include Calibration of Topmodel into 2.5 as it is not part of sensitivity analysis and applies only to catchment scale simulations.

C: Page 14: paragraph starting from Line 4 can be written better by reorganizing a few sentences. The last sentence is important but the plot is not shown. Better show at least an example in one sub-slot either within the plot or next to the plot in Fig 6. Since this will be an important support for your argument.

R: We add a figure showing daily specific discharge at several catchments (below) into Supplementary material; these correspond to different 'goodness of fit' values based on the objective function (eq. 22) value for discharge. Note also that objective function values are already given in Supplementary Table for all catchments.

C: Page 14: 3.4.1- This part does not read well. I see you want to explain the temporal and spatial variability of soil moisture, and relate the variability with drainage and/or ET and its components. However, the current writing mixes them badly. Suggestion: describe Fig 7 well first for temporal variability, and Fig 8 second for spatial variability. For Fig 9 because you talk about it in the next section, so I suggest not to mention it here. Just describe the plots. All explanations can be moved to Discussion.

R: Thanks for good suggestions to improve the flow of the section. Referring to several figures is necessary to refer to specific processes and drivers of soil moisture variability. To improve the clarity and readability according to reviewer comments we make following changes:

- 1) New Fig 6: We merge Fig 6 and upper panels of Fig. 7; specific discharge, precipitation and snow water equivalent timeseries are now shown at top and temporal variability of mean soil moisture and its spatial variance at bottom. At both planes, x-axis is time.
- 2) New Fig 7: The lower panels of Fig 7 (mean soil moisture – spatial variance –planes) now form a separate figure.
- 3) We eliminate referring to multiple figures whenever possible and modify the text for clarity.

C: Line 27-28: Fig 9 is the long-term averaged values, cannot tell anything in between these years, like day 180.

R: agree, reference to Fig. 9 removed

C: Line 30 – to support the rainfall effect, you must plot the rainfall bars in Fig 7.

R: see response above; Figs 6 & 7 modified

C: Page 15: paragraph about SWE - move SWE to the last paragraph, i.e. describe fig 9 before fig 10, avoid mix them for mind-jumping

R: Good point, changed accordingly.

C: Page 16: Discussion – it is difficult to follow and digest, simply because it was badly organized. Currently it gives the impression of no logic of flow. Confusion is caused about what the main points are under discussion. Apparently, the proposed model has the capability to simulate hydrological processes across stand and catchment scales, and sensitivity analysis shows it only has a limited number of parameters significantly influencing the modeling results; Open GIS database application in hydrological model is also mentioned and discussed. Some features that the model has not developed are mentioned in Discussion which I think is unnecessary; and the reason why spatial validation of moisture, ET or SWE should be mentioned in Method validation section, not here. In one word, I would like the authors to think carefully about what they want to discuss or what are the main take-home messages they want to readers to get?

R: The reviewer has correctly found the main points of the manuscript; we try to improve the revised version so that take-home message is more obvious. We will shorten the discussion on potential future developments and lack of spatial validation.

C: Page 18: first paragraph in 4.1.1 can be deleted. Part of the potential applicability of the model has already been mentioned in the previous paragraphs.

R: No actions taken; the Reviewer 1 suggested extending this section.

C: I hope the authors notice that there are many NOT SHOWN in the m/s, which makes the m/s sound incomplete.

R: thanks for noting; the revisions now eliminate this.