Revision (2nd iteration) of the manuscript "hess-2021-202"

This document contains a point-by-point reply to the comments of all reviewers, corresponding author responses and adjustments made in the second iteration of the revised manuscript.

The reviewer comments are denoted with R1-1 (reviewer 1, comment 1) and A1-1 (author response to reviewer 1, comment 1). When changes are made to phrases in the original manuscript, we state the original and adjusted sentence/paragraph or provide the phrase added.

Reviewer #2:

We thank reviewer #2 for taking the time to review our revised manuscript and their additional valuable suggestions, ideas and positive comments regarding our manuscript.

R2 (General comment): The Authors addressed all my comments and the manuscript has been further improved. Despite I still believe that a more consistent approach should be considered to compare simulations and measurements, in my opinion the present manuscript is suitable for publication.

I encourage the Authors to overcome this limitation in future studies to shed new lights on the topic, e.g., simulations should consider real heterogeneous soil moisture conditions, detector response function etc.

A2 (General comment): Thank you very much for your comment! In future studies addressing the heterogeneous soil moisture distributions on the CRNS response, we will include more realistic soil moisture distributions based on additional field observations in neutron transport simulations. In this case, considering detector response functions is highly necessary in order to better reconstruct the observed neutron signal and will be incorporated in the analyses. However, in the present study we would like to show more general results allowing to draw more general conclusions for sites with a heterogeneous (binary) soil moisture distribution instead of reproducing the neutron intensity observed at a specific study site.

R2-1: L255: how was lattice water measured? I would add this information at L115

A2-1: We added this information in the following way:

<u>Addition:</u> "A subsequent loss-on-ignition analysis (1000 °C, 24 hours) revealed an average content of lattice water of 0.03 g g^{-1} for organic and 0.001 g g^{-1} for mineral soils, respectively."

R2-2: L271: what do you mean exactly by quasi-random?

A2-2: We use the term quasi-random to express that the random values generated in algorithms are not fully random due to the nature of the random number generating algorithm. For instance, it allows to set seeds for reproducibility. However, for simplicity, we changed we term to "random" in the entire manuscript.

R2-3: Figure 9 shows same as figure 8a with in addition the color points. Thus Figure 9 could be merged with fig.8.

A2-3: This is correct. However, as we have stated in the point-to-point reply of the initial revised manuscript, we would like to keep Figure 9 to a separate one for better visibility of the figure's content.

R2-4: L466: "After" lower case.

A2-4: Done.

R2-5: L526: two times "and". To remove one

A2-5: Done.

R2-6: L559: if you want to enrich with additional uncertainty assessments you might also add:
. Baroni, G., L. M. Scheiffele, M. Schrön, J. Ingwersen, and S. E. Oswald. "Uncertainty, Sensitivity and Improvements in Soil Moisture Estimation with Cosmic-Ray Neutron Sensing." Journal of Hydrology 564 (September 1, 2018): 873–87. https://doi.org/10.1016/j.jhydrol.2018.07.053.
. Schattan, P., M. Köhli, M. Schrön, G. Baroni, and S. E. Oswald. "Sensing Area-Average Snow Water Equivalent with Cosmic-Ray Neutrons: The Influence of Fractional Snow Cover." Water Resources Research 55, no. 12 (December 2019): 10796–812.https://doi.org/10.1029/2019WR025647.
. Andreasen, M., K. H. Jensen, D. Desilets, M. Zreda, H. R. Bogena, and M. C. Looms. "Cosmic-Ray Neutron Transport at a Forest Field Site: The Sensitivity to Various Environmental Conditions with Focus on Biomass and Canopy Interception." Hydrol. Earth Syst. Sci. 21, no. 4 (April 3, 2017): 1875–94. https://doi.org/10.5194/hess-21-1875-2017.

A2-6: We agree that these publications should be mentioned in line 559 and added them accordingly.

R2-7: L577: point instead of colon?

A2-7: We replaced the colon.

R2-8: L618: two times "the". To remove one

A2-8: Done.

Reviewer #3:

We also thank reviewer #3 for taking the time to again review our revised manuscript and their additional valuable suggestions, ideas and positive comments regarding our manuscript.

R3 (General Comment): I thank the authors for their replies and actions on my comments, especially the checking on Figure 6 (comment R3-1) which, for me, was my only real concern. Actually, the source of my confusion about this figure was my assumption that greater soil moisture anywhere in the simulation domain would always reduce the epithermal footprint. Actually this appears not to be the case if the soil moisture is increased in the near field! This was a novel point to me. And perhaps the authors would like to comment on it. To see this compare epithermal R86 footprints of simulation 1 in set 1 (111 m) and that from set 3 (128 m). I think the lack of change in the epithermal R86 could then be explained by a competition between increasing far-field soil moisture which would reduce R86 and increasing near field soil moisture which would increase it?

A3 (General Comment): Thank you for your comment. Yes, an increasing soil moisture reduces the neutron count rate and thus, the footprint size in the epithermal energy range. This effect is also influenced by the interplay of the different absolute states of soil moisture and their distribution in the model domain.

In Figure 6, we show the results of the simulation sets 2 and 3, where we decrease the soil moisture in both, the near-field and the far-field but at different rates (solid and dashed blue lines). In the near-field, we reduce the soil moisture from 0.35 to 0.1 $m^3 m^{-3}$ in both simulation sets. However, in simulation set 2 (solid line), the far-field soil moisture is reduced to a minimum value of 0.45 and for simulation set 3 (dashed line) to a minimum of 0.2 $m^3 m^{-3}$.

Consequently, in absolute terms, the minimum soil moisture scenario in simulation set 2 is much lower compared to simulation set 3. Due to the non-linearity of the response of neutron intensity and soil moisture and thus, soil moisture and R_{86}, we probably do not see an increase of R_{86} in simulation set 2; simply due to the much higher minimum soil moisture content in the model domain.

Simulation set 2 (solid line) shows fluctuations of R_{86} in Figure 6 which may be linked to the spatial distribution of absolute soil moisture contents and its variations in the model domain but could also be to some degree related to statistical noise.