Reviewer #1:

We thank reviewer #1 for taking the time to review our manuscript and their valuable suggestions regarding our manuscript. We are certain that these comments greatly improve our manuscript and they will be incorporated in a revised version of the manuscript. In the following section we will reply to all comments of reviewer #1 with R1-1 (i.e. reviewer 1, comment 1) and A1-1 (i.e. author response to R1-1), respectively.

R1-1: The figure legends and axis labels are too small. Please enlarge before publication.

A1-1: We will enlarge axis labels and legend labels of figures in a revised version of our manuscript.

R1-2: L444. The authors argue that the thermal neutron footprint may be significantly deeper than the epithermal range of ~30-40 cm. If this is indeed the case additional profile sampling of soil chemistry is needed by the community in order to understand the distribution of trace elements (e.g. Gd and B) that may greatly impact the thermal neutrons. In particular, as the neutrons interact with more soil horizons (beyond the O and A typical for epithermal) soil chemistry may play a greater role. The authors point this out a little but should highlight the need by the community to sample more soil horizons for relevant epithermal and thermal neutron soil chemistry. Avery et al. 2016 and others have presented a nice lattice water dataset for the top 30 cm but it seems the community needs to expand this effort across CRNS sites and more soil horizons.

A1-2: The integration depth of thermal neutrons remains under debate. We found that the average measurement depth (D_{86}) strongly depends upon the definition of integration depth. If the point of thermalization (i.e. the point where a neutron first reaches a thermal energy) is used, the measurement depth is slightly shallower then the one of epithermal neutrons while it becomes much larger when the maximum depth along the complete neutron transport path is used. We intended to show that more research is needed in order to understand the thermal neutron transport under different environmental settings and cannot deliver a final solution on the definition of the integration depth of thermal neutrons. However, we will add a sentence regarding the potential implications of a larger thermal measurement depth with respect to soil sampling and information on soil chemistry to a revised version of this manuscript.

R1-3: L475. The authors show the heteroscedasticity effect from local and far-field soil moisture changes on the thermal and epithermal scatterplots nicely in Fig 8A. Without the soil moisture data in the peatlands, the conclusion is somewhat more speculative based on GW depth but still compelling. However, additional CRNS sites with largescale irrigation (60 ha) from center pivots may confirm this effect (CRNS sites exist in NE, KS, and IA in the USA with center pivots). As the center pivots water in pie slices over 48-72 hours they will create this near and far-field effect, particularly when compared against a rainfall event on-site. The authors could mention this experiment as future work needed by the CRNS community to help confirm the conclusions here.

A1-3: We agree with the reviewer, and had in fact already included a similar idea in a proposal. Accompanied with intensive soil sampling or in-situ sensor networks as well as neutron transport simulations, such experiments could also help in finding supporting evidence for the measurement radius of thermal and epithermal derived from neutron transport simulations in numerous studies during the past decade. For instance, and with respect to this study, such an experimental setup could help finding an answer of whether using the point of thermalization, the point of the first soil contact or a different characteristic of a simulated detected thermal neutron for calculating the footprint radius. We will add this information at the end of chapter 4.2 (L. 496) of a revised version of this manuscript as stated below.

<u>Original:</u> “However, this requires further research regarding the relationship of thermal and epithermal neutron intensities under changing soil moisture and with respect to different environmental factors such as soil chemistry. This may also require the need to develop transfer functions for thermal neutrons similar to those already available for estimating soil moisture from epithermal neutron intensities (e.g., Desilets et al., 2010; Franz et al., 2013; Köhli et al., 2021).”

<u>Adjustment:</u> “However, this requires further research regarding the relationship of thermal and epithermal neutron intensities under changing soil moisture and with respect to different environmental factors such as soil chemistry. As study sites are always restricted to local boundary conditions, large scale irrigation experiments using e.g. center pivots combined with neutron transport simulations could improve and extend the insights gained in this study regarding indicators for footprint heterogeneity as well as the definition of measurement footprints in general. Additionally, this may also require the need to develop transfer functions for thermal neutrons similar to those already available for estimating soil moisture from epithermal neutron intensities (e.g., Desilets et al., 2010; Franz et al., 2013; Köhli et al., 2021).”

R1-4: Need space “time seriesNET”

A1-4: We will add a space.

R1-5: Figure 3. check legend and data time series in panel B? No red squares etc.

A1-5:. In figure 3, panel b), the colours are correct but indeed the point symbols are not. We apologize for this mistake and will correct it.

R1-6: L538. Also, watch out for overfitting if only calibration data is available on campaign days. The CRNS community has found ~3 calibration dates are needed for robust N0 estimation. For 4 parameters you may need 12 or more calibration sampling days. That is a lot of digging :). It is already challenging to calibrate on multiple days if you have several CRNS sites.

A1-6: We agree with the reviewer. As stated in the manuscript (L. 540), adjusting the parameters requires a sufficient spatio-temporal coverage of a sufficient number of reference measurements. In this study, permanently installed point sensors were used which provide continuous data and thereby support the calibration process. We believe that further soil sampling campaigns would be time-consuming, labour-intensive, and not add to the already continuous dataset.