Review of MS No.: gi-2021-18
Francke et al. Assessing the feasibility of a directional CRNS-sensor for estimating soil moisture

General comments

The Authors present an interesting and valuable study on the feasibility of directional cosmic-ray neutron sensing (dCRNS). This scanning method could help the interpretation of the signal at specific sites with e.g., land use patches and it could provide some new opportunities for integrating the method for new applications. The manuscript is generally well written and clear and the analysis is based on several numerical simulations. For these reasons I think the study can be a valuable scientific contribution. I have however three main concerns that I think should be considered: [1] to add the experimental results; [2] to improve the quality of story-telling and [3] to strengthen the scientific value of the study with a more clear outlook. Despite these might require some additional work, I believe that the Authors will be able to well address my concerns. Some few specific comments are listed below that I hope can also help the overall improvements of the manuscript.

General comments

[1] At the beginning of the manuscript a direction CRNS sensor has been introduced (fig1). Simulations are based on this sensor design. Surprisingly for me, no experimental results has been shown and discussed in the present study. Why that? I believe that some data have been collected since it is stated that this prototype has been constructed since 2018 (L69). I think adding experimental results would strengthen the value of this study.

[2] The manuscript well covers and discusses the methodology, the results and the limitations of the study. Despite I do not see any critical missing parts, I found the story line not always clear or a bit difficult to read. I think the manuscript could be improved by re-organizing especially the method section in a more synthetic structure that can be appreciated and understood even without reading all the details. A table summarizing the different scenarios simulated could also help the readings.

[3] The final result seems to be that scanning CRNS is hardly feasible and only strong soil moisture changes and patches could be detected with long integration time. Despite I believe that scientific papers should also present and discuss “what does not work” to provide guidelines for further studies, I usually expect that from lab-field studies where it is hardly possible to repeat or to increase the numbers of experiments. In contrast, all the results of the present study are based on simulations. The Authors well discuss some limitations on the numerical settings and they often acknowledge that further simulations could shed lights on how to design an effecting settings (e.g., L411, L428, L438). The Authors conclude for instance that progress in detector technology and optimizing the shielding towards wider FOVs but more specificity could alleviate some of the restrictions and make directional scanning a useful tool for tailored use of CRNS (L501-502). I believe that the scientific value of the present study should be improved not speculating on that. Instead few specific additional simulations could support the design of a proper scanning CRNS in the future. Specifically, I personally suggest to consider a hypothetical very high sensitive sensor with a cone-shaped shielding (smaller angles) that has been shown in literature to be able to discriminate directional neutron fluxes but not in the context of soil moisture observations (see Becchetti et al, 2015). Alternative (or additional) settings based on the experiences of the Authors could be also considered. Despite I agree (see your comments at L442) that these set-ups could be not very practical nowadays considering among others the need of high sensitive (and probably expensive) sensors, it could be probably feasible in the near future considering

current sensors developments. At such, the present study would provide a strong bases for further sensor development. At the present status, this is not the case.

Specific comments

L66. As far as I have understood, side-shielding has also been suggested for addressing neutrons form below-sensor in the so-called “road effect” by Schrön et al. 2018? If this is the case it is worth extending here the discussion with this example and clarifying that directional shielding has been presented for discriminating neutron fluxes in the vertical directions but so far not focusing on lateral side-directions.

Schrön, M., R. Rosolem, M. Köhli, L. Piussi, I. Schröter, J. Iwema, S. Kögler, et al. “Cosmic-Ray Neutron Rover Surveys of Field Soil Moisture and the Influence of Roads.” *Water Resources Research*, May 14, 2018. https://doi.org/10.1029/2017WR021719.

L69-80. These descriptions could better fit the methodology section.

Section 1.3 fits better the methodology section, in my opinion.

L117-121. Based on this explanation, I would have expected that directional shielding is not feasible.

L179. Remove “it”

L182. There is a quite long discussion on non-epithermal neutrons. Most of this contribution, as far as I have understood, comes from thermal energy neutrons (20%). But it is then stated the Thermal neutron transport was disabled for reasons of computational speed. I’m a bit confused by the importance of this discussion and the detailed description at L101-113.

L186. Remove one “the”

L310. As far as I have understood, currently all are neutron simulations. Why then the need of the title section 3.1?

L487. I suggest specifying full name in the conclusions

L501. I strongly encourage the Authors to provide more insights on how optimizing the shielding (see general comment [3]).