Review of the manuscript Signal contribution of distant areas to cosmic-ray neutron sensors – implications on footprint and sensitivity by Schron et al.

Summary

The manuscript is well written and structured. The topic is relevant. The analyses well performed and discussed. The Authors have also provided an on-line tools for calculations that might be useful. I have only few main comments and some more specific/technical suggestions that are listed below. Once addressed, I think the manuscript can be suitable for publication.

Main comments

[1] In my opinion, one of the strongest assumption that might be warranted is that neutron contribution of each sub-domain can be assessed individually (L149). As far as I have understood, this is also actually not challenged by the MonteCarlo simulations because also in these analyses the distance of the first contact with the land is used for the calculation (L179 and L212). In contrast, assuming a more diffuse transport process I expect more interactions and mixing. This might change significantly the results. I would say that for addressing this question, a different definition of detected distance in the MonteCarlo simulation should be tested. If this will not the case within the present study, I suggest at least to extend the discussion around that.

[2] I like the practical question that has been formulated, i.e., "At what distance are soil moisture changes still visible to the CRNS" (L325). This could help better understanding neutron signal and supporting agro-hydrological applications. However, I'm not convinced that this should be posted as an alternative definition of footprint size R86 (L324). As far as I understood, on the one hand, R86 refers to the average radius over all the directions from the sensor (as stated at L365) and it does not assume that no neutrons are coming from more remote areas (on the contrary to the statement at L367). On the other hand, the Authors nicely show how soil moisture changes at a field nearby can be detected only at different distance than R86 in case soil moisture where the sensor is placed remains constant. But this does not contradict R86, i.e., on average over all direction R86 is different then the new R. Moreover, I do not have anything against these showcases but I think these support the conclusion that CRNS is not suitable for supporting irrigation management at relative small farms. But this I think was already clear from first CRNS publications. In contrast, it should be acknowledged that in any other conditions we soil experiences wetting or drying soil moisture profiles even if at different degrees that is still detected (even if in a non-linear way) by the sensor. So overall, I see the new R as an additional indicator rather than an alternative footprint size, i.e., I would still like having an indicator that accounts for neutron intensity changes in all directions (L365).

[3] my final main comment is related to the fact that all the discussion is based on a forward operator N(theta) (eq. 11). I agree that the results of this contribution will support some practical questions, e.g., where to install the sensor or modelling applications, e.g., data assimilation. However, I believe that in several applications soil moisture is the targeted variable, i.e., we do not know soil moisture within the footprint. Thus, I think one could conclude that 1) it remains an ill-posed problem to try to resolve soil moisture variability within the footprint and 2) CRNS sensor should be strategically located to avoid difficulties with signal interpretation. I would encourage the Authors to extend on these.

Specific comments

L2: Through the manuscript, the Authors use the term "concept" to refer to what they have developed

and tested. A concept is in my opinion an abstraction or perception. So, more than a concept, the Authors have developed an “approach” or a “method”. I suggest using one of these terms instead of using “concept”.

L3. I understand that similar concept (or approach, see comment before) can be developed for snow. But the study focuses on soil moisture and the snow application is not addressed. I would remove from abstract and methods the snow applications and only refer to that as a possible extension o the study in the conclusions section.

L11. “Long lasting question” is strongly CRNS community oriented. I would relax the sentence.

L34. I would not call these “problems”. Maybe aspects, assumptions?

L47. More than unexpectedly, I would say that changes are expected but complicate to quantify

L55 add “soil” hydraulic conductivity to be more precise

L86. Why only humid?

L88. Vegetation height might be not a good proxy for biomass effect to the neutron signal. I guess it was selected for simplicity but would be nice to extend the discussion on the consequences of this approximation.

L141. Not sure if they rarely occur. Assuming for instance an installation at a border of the field, it may be the rule that below the sensor we have very different conditions than the surrounding areas.

L172. What is “drf”?

L193. I lost from where these ranges come from.

L249-250. As highlighted at L199, it is expected that highest contribution is evident for areas that are closer to the detector and dryer than others. What it is formulated in the present manuscript is an analytic approach to quantify these contributions. For this reason the sentence should be rephrased.

L252. The changes in the shape has also been detected for snow application. It might be worth citing and extending the discussion with that. See:

Schattan, Paul, Gabriele Baroni, Sascha E. Oswald, Johannes Schöber, Christine Fey, Christoph Kormann, Matthias Huttenlau, and Stefan Achleitner. “Continuous Monitoring of Snowpack Dynamics in Alpine Terrain by Aboveground Neutron Sensing.” *Water Resources Research* 53, no. 5 (May 1, 2017): 3615–34. https://doi.org/10.1002/2016WR020234.

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.

L328. As “IT” has been shown.