

Hydrol. Earth Syst. Sci. Discuss., referee comment RC1  
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## **Comment on hess-2022-123**

Anonymous Referee #1

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Referee comment on "On soil bulk density and its influence to soil moisture estimation with cosmic-ray neutrons" by Mandy Kasner et al., Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2022-123-RC1>, 2022

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### **GENERAL COMMENTS**

This paper comprehensively addressed the effects of soil bulk density on soil moisture estimation using cosmic-ray neutron sensing technique. The authors did a series of neutron simulations on a wide spectrum of soil bulk density and soil moisture. The simulation results were verified by conducting lab experiments of 4 scenarios sequentially. The effects of the bulk density were manifested by applying two widely used conversion equations on the simulation results. The authors also provide a correction approach for the CRNS community.

Overall, I think the authors did an acceptable job on simulation and lab experiment. However, the current version of the manuscript is not coherent or cohesive. There is plenty room for improvement in results presentation, content organization, and writing. Detailed suggestions and corrections are listed below.

### **SPECIFIC COMMENTS**

#### **Relationship to lattice water and organic matter**

I am curious about if any effects of lattice water that has already been considered in the lattice water correction are considered again in the bulk density correction. The case with organic matter is similar. As mentioned in Line 267-269, mineral soils without any organic

parts were considered. However, the low bulk density of soil is usually the consequence of high content of organic matter. In practice, if I apply both the organic matter correction and bulk density correction to my neutron counts, do I over-correct it?

## **Objectives and conclusions**

The last two paragraphs of the introduction section need to be largely modified or rewritten. The hypothesis is only mentioned in this section but was not explained in detail how it is rejected/accepted and according to what criteria. To make the conclusion address the introduction, the objectives should be somewhat like 1) investigate the influence of bulk density in CRNS soil moisture measurement, 2) quantify the influence by examining the sensitivity of neutron counts through a large spectrum of soil bulk density, 3) assess the impact of bulk density on the two major conversion functions, and 4) develop a novel correction method/parameter for practical use.

## **Presentation of the results**

The study provides substantial amount of simulation results. Many figures are clearly plotted and very informative. However, I feel a little awkward reading some of the figures. Based on the simulation and experiment design, I expected more figures like Fig. 5 with soil moisture as x-axis, and porosity contour lines, instead of the opposite, like Fig. 3. The presentation of Fig. 5 is similar to Fig. 6 in Zreda (2012) which is probably more common and easier to read in published literature.

The lab experiment is of great value to this study, which could potentially provide a great validation dataset for the simulation. I wonder if there is any experiment on varying soil moisture conducted on this setup. It would be great if there were more points on Fig. 3 or a separate figure of  $N_{\text{exp}}$  vs.  $N_{\text{simu}}$ .

For Fig. 3 specifically, only 2 of the 4 experiment results were plotted in the figure. They were not colored with the soil moisture color scheme, which can barely inform the readers with the performance of the simulation/experiment. I suggest plotting a zoom-in panel of the four points with four ideal contour lines of the soil moisture content equal to the four measurements. The four points should also be colored with same color scheme.

## **Notation**

The notations in this paper are generally clear but some selections are not very common. For dry bulk density, I think  $\rho_b$  is more common and  $\rho_s$  is often used as the density of solids instead of bulk density, which may cause some confusion.

For Section 3.1, "soil-water ratio" may be better named as "solid-water ratio". You may assign this ratio with a symbol since it is also used in Table 1 and Section 3.3.

### **The correction factors**

Some of the correction factors depend on soil moisture, which doesn't really "go in line with the traditional correction factors for atmospheric changes..." (as mentioned in Line 337), since I think the correction factors should be independent of soil moisture. Line 374-375 mentioned a TDR sensor. Does it mean that a point-scale measurement or some rough estimate can also work here?

### **TECHNICAL CORRECTIONS**

(not a complete list)

Line 28: in the soil -> In the soil

Line 98: Add definition of  $N_0$

Line 150: what is "DIN 18 125 T1 and T2"?

Line 176: Describe the y-axis. Is the "simulated neutron counts" with a. u. (arbitrary unit?) the same with the "neutron counts (normalized)"?

Line 208: section 2.2 -> Section 2.2 (many similar ones throughout the manuscript)

Line 209: Add " in Koe. Function" before "(Eq. 8)"

Line 214: Extra space before "Eqs. 5"

Line 227-228: delete "above" and "less than"

Line 249: Fig. 3) -> Fig. 3a)

Line 254: (Fig.3) -> Fig. 3b)

Line 260-261: Any reference for the classification of bulk density? If the medium dense soil is between 1.6 and 1.8, this classification is not complete. For example, 1.5 g/cm<sup>3</sup> doesn't belong to any category.

Line 296: (6) -> Fig. 6

Line 340: section 2.2 -> Section 2.1

Line 356: based on; is only depend on -> only depends on

Line 358: the logic chain is broken between the two sentences

Line 370: extra "an"

Line 400: delete "small"

Figure 1: Instead of randomly giving 2 examples of the 7 simulations, describe the 7 simulations with the aid of Figure 1.

Table 1: Description of this table is not complete in the text. The column "differential" has different meanings across rows since the last row is in percentage. It is also mentioned as "deviation" in the text.

For Section 3.3, does it aim to verify/validate some of the simulation results? If so, consider renaming this section. The "previous section" (Line 206) is Section 3.2 or 3.1? If 3.1, consider switching/merging Section 3.2 and 3.3.