

Earth Syst. Sci. Data Discuss., referee comment RC1
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Comment on **essd-2021-445**

Anonymous Referee #1

Referee comment on "Soil moisture observation in a forested headwater catchment: combining a dense cosmic-ray neutron sensor network with roving and hydrogravimetry at the TERENO site Wüstebach" by Maik Heistermann et al., Earth Syst. Sci. Data Discuss., <https://doi.org/10.5194/essd-2021-445-RC1>, 2021

General comments:

In this article the authors present an impressive data set encompassing measurements of various parts of the hydrologic cycle with a specific attention to mid-scale soil moisture observations. I acknowledge the value of this data set, in particular with regards to the exploration of cosmic ray neutron sensing. The manuscript is written in very good style, it is structured, clear and easy to follow.

The only really major criticism I have concerns the calibration of the stationary cosmic ray neutron sensors (CRNS). It has been shown that highly variable systems like temperate forests require calibration for at least two points in time (one dry state and one wet state of the system, preferably), (see, e.g., Heidbüchel et al., 2016; Tan et al., 2020). Having the SoilNet sensors with continuous monitoring available, this can be done – however, the SoilNet does not cover the entire footprint of all the CRNS. Instead, one manual soil core sampling campaign was conducted to ‘fill in the gaps’ and get additional data on bulk density, lattice water content, etc. This allows for the proper calibration of the CRNS at (only) one point in time. I would expect a discussion of this deliberate choice to only use one point in time for calibration – in particular noticing the fact that in your case the calibrated CRNS seems to consistently overestimate soil moisture during the dry periods.

All data is accessible through the links provided and presented in a clear and structured way.

Specific comments:

Abstract, Line 7: Do you mean 'watershed boundary'? 'Watershed' alone can also mean the catchment.

Line 283-284, 307: In order to calibrate a CRNS properly it is recommended to independently measure soil moisture twice (preferably under wet and under dry conditions, see, e.g. Heidebüchel et al., 2016; Tan et al., 2020). Also, it is recommended to have ~18 different sampling locations within the footprint of a CRNS (see Franz et al., 2012). For many of the CRNS this requirement is not fulfilled. How do you justify this? At least it would be added value to provide a two-point calibration.

Line 311: What are these 18 locations? In Figure 2 there are more than 18 locations marked with 'manual sampling'.

Line 317: I guess that is where the extra 'manual samples' derive from. I would mark them differently in Figure 2. (I really want to know where you did the soil core sampling).

Line 357: Why won't you tell us the exact number of plots in the grassland and in the shrubland areas?

Line 409: What do you mean by 'complemented'?

Line 445-448: You only used one date (and one condition) to calibrate N0, although you have SoilNet values for all kinds of soil moisture conditions. That is dangerous and potentially weakens the measurement performance of the CRNS. You can see in Fig. 4b that the CRNS overestimates soil moisture in dry conditions – this could have been avoided with another calibration performed when it's dry.

Also, what about the manual samples from the soil cores, did you use them at all for calibration? If so, how did you incorporate them? If not, why not? After all, SoilNet does not cover the entire footprint of all of the sensors. At least, I would like to see this discussed.

Technical corrections:

Abstract, Line 15: 'hillslope' instead of 'hill-slope'.

Abstract, Line 16: '...the retrieval OF soil water...'

Line 39: 'Soon enough...?'

Line 41: Schrön et al., which year?

Line 350: '...of the forest IS rather homogeneous...'

Line 363: raspBerry.

Line 402: '...groundwater depth...' (no space between ground and water).

Line 403: North Rhine-Westphalia is the English word.

Line 438: 'Thenceforth' is quite archaic and literary. I have never seen it used in a scientific paper.

Figures:

Figure 2: The number of manual soil samples taken for some of the CRNS may not be sufficient (fewer than 18) for giving a statistically robust mean value (in some cases not even if you also include the SoilNet sensors within the footprint).

Literature:

Franz, T. E., Zreda, M., Rosolem, R., and Ferre, P. A.: Field validation of cosmic-ray soil moisture sensor using a distributed sensor network, *Vadose Zone J*, 11(4), <https://doi.org/10.2136/vzj2012.0046>, 2012.

Heidbüchel, I., Güntner, A., and Blume, T.: Use of cosmic-ray neutron sensors for soil moisture monitoring in forests, *Hydrol. Earth Syst. Sci.*, 20, 1269–1288, <https://doi.org/10.5194/hess-20-1269-2016>, 2016.

Tan, X., Zhang, L., He, C. et al.: Applicability of cosmic-ray neutron sensor for measuring soil moisture at the agricultural-pastoral ecotone in northwest China, *Sci. China Earth Sci.* 63, 1730–1744, <https://doi.org/10.1007/s11430-020-9650-2>, 2020.