

Quick response to the reviewer comments on the paper titled “Integral quantification of seasonal soil moisture changes in farmland by cosmic-ray neutrons” by Rivera Villarreyes, Baroni, and Oswald

We highly appreciate the constructive comments of reviewer and respond briefly to the major points.

The major interpretation problems are identified at the very end of the manuscript (p.6889 l.8-11 and l.14-20). They argue that only the hydrogen (H) present in environmental compartments that vary in time on a seasonal scale need to be taken into account for monitoring changes of soil water storage below- and aboveground. However, to extrapolate the calibration parameters from gauged to ungauged sites, one apparently needs to include all significant H-pools. The soil organic matter (incl. wet leaf litter and raw humus in forests), the presence of organic matter and water in the canopy, and the ice in the soil and snow pack affect the site-specific parameterisation. This partly explains the massive discrepancy between the parameters obtained in this study and those reported by Zreda et al. (2208). and

p.6877 l. 21. The volumetric content of H in organic matter (let us say 2-3 % by weight) is not negligible compared with an average (volumetric) water content of 0.15

True. The organic matter is a point when trying to transfer the calibration parameters to other sites. However, it only adds to the CRS “background” level for dry conditions, as do other soil components. Therefore it is not having the same potential influence as biomass water that acts as a **changing** water storage influencing the CRS measurements. However, the other quantities mentioned (wet leaf litter and raw humus, water in canopy, ice and snow) do change. The first two play a lesser role in respect to biomass for fields with agricultural crops which is the focus here (cf. title), opposed to forests. Ice in the soil is counted by the CRS measurements. Snow pack is another issue to be discussed separately, not so much affecting our site-specific calibration, but added a temporally changing water storage compartment; however, for different periods than the cropped biomass, at least in our study (summer – winter).

p. 6890 l. 27. This is a courageous extrapolation : sandy soil of Northern Germany are not really “the majority” of Europe’s soils ... be careful with such statements. [and similar by reviewer #1]

We will rework the conclusions on footprint, transferability and soil effects based on the reviewers’ comments to achieve more carefully phrased statements.

Soil freezing and the role of snow is recognized as being a significant factor. In this context the reasoning in this paper is quite superficial. The Theta-probes do not produce outliers during frost periods (with bare soils) that mess up the calibration but they measure the liquid water content only (the dielectric constant of ice is less than half of that of water). [similar reviewer #1]

We will include a better explanation concerning to these points. On one hand we will in more detail discuss existing work on snow influence (e.g. by Kodama et al.) on measured neutrons. Also, we will estimate snow water mass equivalent instead of referring to snow height only. On the other hand, we will state clearly, that for freezing conditions the MR2 readings are not representing total soil moisture, but give a lower limit to it, because frozen water has a reduced dielectric constant. In this sense they are not working the way we need it to be useful as soil moisture measurements or even testing the CRS. However, in the revised manuscript we will describe that more adequately.

I do have a problem with the notion 'cosmic ray sensor'. The Geiger-Müller counter counts the thermalized neutrons (or faster neutrons when shielded) that means, the density of thermalized and only partly attenuated neutron density aboveground and not the cosmic rays per se. If the acronym is already sort of a 'terminus technicus' then not much can be done with this terminological imprecision. [by reviewer #3 (H. Flühler)]

We absolutely agree. To name it cosmic ray sensing is indeed misleading, but we wanted to follow this phrasing according to the work of Zreda and Desilets and colleagues, to make clear we use the same method. However, maybe there is still time to introduce a better name, which we now plan to do after explicitly referring to the naming used so far. An option would be to call it "neutron background radiation sensing" (NBRS).

p. xy I... there are many more possibilities to eliminate editorial problems. My notes are just examples. [similar by reviewer #1].

We will improve the final quality in revised manuscript based on the various suggestions provided by all three reviewers, and our own, additional efforts.