

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.

I have one comment on the calibration. Multiple soil moisture levels were used in calibration, giving different sets of calibration constants a_0 , a_1 and a_2 . With these different constants the shape of the calibration function changes. Instead of one calibration function, you have more than one. This seems incorrect. The shape of the calibration function for a given site should be constant. Perhaps what you mean is that the constant shape of the calibration function is approximated more than once? [Related comments also by reviewers #1 and #3]

In this manuscript, we suggest a procedure to ease the practical application of the method without the need of modeling neutron scattering or locations with a deep soil monitoring network, based on intensive but practical monitoring activities.

Some specific points are:

- Calibration procedure – There is only one calibration, resulting in a single set of calibration parameters. In difference to standard calibration procedures for other types of devices, we decided to use not all data from the first measurement period, but only three selected short-periods within. These periods are chosen to cover a range of medium moist conditions, with (presumed) reasonably similar moisture in the penetration depth of the CRS and the close-to-surface soil measurements. The CRS-derived soil moisture outside these three short-periods is not adjusted by calibration of the parameters and thus could be counted for testing the method.

- Validation – For the whole winter period the single, original calibration parameters were used. Outside the periods with snow cover, which has its own specific influence, this could be taken as validation, on top of the intermediate periods from the summer campaign (see above).

- Penetration depth and calibration – We are very aware of the fact that local soil moisture measurements in different depths will improve the calibration and testing of the CRS-method and a better assessment of the actual penetration depth, depending on soil moisture itself. Notwithstanding, we have assessed the method and applied it based on common and practicable FDR measurements representing the topsoil surface only, in its own right.

- Calibration function – The mathematical form of the calibration function is based on the results from Desilets et al. (2010) and is a fit to values resulting from a statistical simulation of neutron transport at the soil-atmosphere interface, fully based on physical principles. Thus it is more than an empirical function, allowing also evaluating values (somewhat) outside the range of measured soil moisture values

used for calibration. It also can be transformed mathematically, if a different counting rate N_0 , e.g. a lower one, shall be used for normalizing the count rates, resulting in a different value of two of the three calibration parameters. This dependence is also a reason why calibration parameter values differ from the ones reported by Desilets et al. (2010).

Plotting the difference between thermal and epithermal measurements is a standard approach in neutron physics. But when one detector is moderated by plastic, as it is the case here, the difference method will not work as well as in the case of epithermal neutrons (which are measured without artificial moderator). So I am not sure what the difference can tell us, or even if it has meaning. Perhaps you can consider looking at the ratio of fast to thermal? This said, I do like the fact that you try to link the two energy levels and interpret the difference in terms of field conditions.
[by Reviewer #2]

We showed a plot of slightly different properties than usual in neutron physics, which the reviewer may not have noted completely. Because we do not have energy selective detection or simulations we only described plotted variables in terms of "moderated" and "bare" counters, indicating only the shift in neutron energies. However, these are the values that researchers can obtain from the CRS probe, and as they show actually there is a difference between counting ratios for snow and non-snow conditions, which could at least be used as indicator for snow modifying the counts, even without snow cover measurements. However, we will make clear in the text between precisely known energy ranges of neutrons and the quantities we plot in the diagram.

I did make numerous suggestions how to improve the writing. They are listed below in section DETAILS. These are just suggestions, so the authors can disagree and ignore them.

We will take most of the suggestions provided by reviewer # 2.