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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Calibration approaches of cosmic-ray neutron sensing for soil moisture measurement in cropped fields" *by* C. A. Rivera Villarreyes et al.

Anonymous Referee #3

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General:

The authors present various calibration approaches for cosmic ray soil moisture sensing based on only 5 locations with FDR measured soil moisture. The calibration approaches vary in the choice of the specific time period within the growing period and in the treatment of penetration depth as well as in the choice and number of fitted parameters. Parameters describing the dynamics of biomass are not included in the calibration. Unfortunately, the manuscript is not well structured and is badly written – this makes it very difficult to understand and follow. I was disappointed as the title lead me to expect calibration approaches that actually accounted for the dynamics in

vegetation.

Specific Comments:

Abstract: It would be good to have some more details in this abstract, especially on the differences in field calibration approaches and on the different ways of soil moisture profile integration. Also, what is CRS parameter variability? What are the parameters to begin with? You do not have to become too specific, but some more basic information would be helpful. Report on the actual results from your study apart from saying that 'the calibration needs to be adapted'.

p. 4238, l. 9: What do you mean with '. . .was calibrated against a network of. . .'? There was no "network" there were only 5 measurement locations.

p. 4238, l. 13: Better write: '. . .a single set of parameters that perfectly estimates. . .'

p. 4238, l. 14: Better write: '. . .could be understood by certain crop. . .'

p. 4238, l. 13-15: How can the parameter variability be understood by predicting the attenuated neutrons by crop presence? These lines are unclear and need to be rephrased

p. 4238, l. 16: Better use: '. . .the potential of cosmic-ray. . .'

p. 4238, l. 17: that calibration needs to be adapted to seasonal changes in vegetation is not really a new finding in my opinion. Isn't this a known effect due to the physics of the measurement.

p. 4238, l. 20: '. . .it is of great interest to several important aspects. . .'? How is something of interest to an aspect?

p. 4239, l. 13 and 18: You introduce those papers (Zreda 2008 and Desiltes 2010) twice.

p. 4240, l. 7: You should not just write subordinate clauses like: '. . ., meaning possible

correction factors' but explain what you mean by this. The end of this sentence does not fit to the beginning anymore.

p. 4240, l. 9: '...to other times...' is what you write, what you mean is '...to other periods of time (like seasons, moisture conditions, etc.)...'. Please be more specific.

p. 4240, l. 16: Please be more specific. What do you mean exactly by '...extending knowledge of the cosmic-ray neutron sensing to different crops.'? Do you refer to the understanding of the sensitivity of the measurement here?

p. 4240, l. 21-22: how did you determine that the soil is homogeneous?

p. 4240, l. 23: You applied the method when the field was cropped with corn in order to do what? How is the other study related to this one? When you add this information you should give more details.

p. 4241, l. 12: If you do not use the data from the bare counter you should not mention that counter in the description here.

p. 4241, l. 19: Uncertainty increases in low latitudes due to more damping of incoming neutrons on their way through the atmosphere. p. 4241, l. 19-22: these sentences need to be rephrased; it is not clear what you are trying to say here.

p. 4241, l. 23-29: why did you choose to measure soil moisture only in 5 locations? This number of measurement locations seems to be very small compared to the large footprint of the CRS method. You also have to explain your rationale of why you do not stick to the recommended grid based core sampling procedure.

p. 4241, l. 27-28: what were the input values for equation 1? From how many samples were they averaged and what was the variability? What was the theta you used here?

p. 4241, l. 29: Do you mean that soil texture does not change in the first 50 cm or do you mean that the way soil texture is measured does not change? This is just an example, but also generally more precision in your formulations is necessary.

p. 4242, l. 2: soil cores were extracted twice at the same locations? Once during the sunflower and once during the rye period? Explain why you think that the FDR calibration needs to be repeated for different crops. Is this due to different root densities? Or did the locations change?

p. 4242, l. 6-7: field calibration? Unclear, needs to be explained.

p. 4242, l. 8-10: you took daily measurements of crop height? Please phrase this sentence more clearly. Why did you not take LAI, % of area covered and other measurements to describe vegetation biomass dynamics?

p. 4242, l. 16-26: this paragraph needs to be improved – the processes are not well explained and the wording is confusing.

p. 4242, l. 17: How can these neutrons be randomly distributed above ground when they penetrate the soil? This whole paragraph is unclear and should be rewritten.

p. 4242, l. 19: soil nuclei?

p. 4242, l. 25: mathematical function does not seem to be the right word here

p. 4243, l. 12: What is Ctheta? I cannot find it in equation (1).

p. 4243, l. 15: "Corrections" is too vague as a heading here.

p. 4243, l. 20: it sounds as if you have set up = installed the reference station

p. 4243, l. 22: What type of relationship did you assume? A linear one? Please cite a reference here.

p. 4244, l. 2: You say 'On the one hand...', but there is no 'on the other hand...' anywhere.

p. 4244, l. 3: More details on this Monte Carlo simulations, please. You need to put it into a context. Also: Did you do this type of Monte Carlo calibration or are you just explaining that Desilets did it that way?

p. 4244, l. 4: In the equation proposed by whom?

p. 4244, l. 5: . . .and fast neutron count. . .

p. 4244, l. 12: 'Better approaches' in regard to what? What are they supposed to do better?

p. 4244, l. 15: "with respect to the parameters of Desilets" – this is unclear and needs to be rephrased

p. 4244, l. 19-22: which of these two approaches did you use?

p. 4244, l. 22-23: did you also validate your calibration? How? Using which periods? Needs to be explained.

p. 4244, l. 23: You mean the RMSE between soil moisture derived from FDR and soil moisture derived from CRS not just the measuring devices FDR and CRS. Again, be more precise with your formulations.

p. 4245, l. 13-15: seems quite arbitrary. Why not use eq. 1 with mean theta?

p. 4245, l. 20: '. . .detected neutrons do not originate uniformly distributed in depth'. What do you mean? Please formulate in a less convoluted way.

p. 4246, l. 3: '. . .which may depend on nuclear properties of the porous medium.' What are these 'nuclear properties' and what decides whether k is dependent or not?

p. 4246, l. 3-4: how did you calibrate k values from the FDR soil moisture?

p. 4246, l. 10: What do you mean by '. . .z is only available at depths of 5 cm. . .'? I thought z itself is a depth.

p. 4247, l. 17- p. 4248, l. 18: these paragraphs are a mix of results and methods – please restructure and move the methodological aspects to the methods section

p. 4247, l. 25: when were these campaigns carried out? How was soil moisture measured?

p. 4248, l. 3-4: did you just use the 5 near surface values for the determination of the mean?

p. 4248, l. 15-18: more detail needed here

p. 4248, l. 19: is neutron correction the correct term here?

p. 4248, l. 22: decreased or decreasing? If there was a decreasing trend – why is your correction factor constant in time? Section 3.3: if I understand correctly you are applying the calibrated parameters determined from specific time periods to the entire time period of measurements and are evaluating the overall RMSE? Does this make sense? Wouldn't it be more intuitive to apply a time-variant calibration with respect to the dynamics in biomass? How do the RMSE of the calibration period compare to the RMSE of the entire period?

p. 4249, l. 7: this refers to eq. 1?

p. 4249, l. 12-14: unclear, please rephrase

p. 4250, l. 10: . . . with respect to your data set and study site.

p. 4250, l. 11: how did you apply the variable penetration depth to the time series? Is this based on eq. 1 and the mean soil moisture measured with the FDR sensors?

p. 4251, l. 21 and 25 the same finding is repeated here.

p. 4251, l. 19-25. How did these calibrated N0 values compare to the measured N0 values used for the other calibrations?

p.4252 l. 8-10: which figure are you referring to?

p.4252 l. 11-12: why did you decide to use only the calibration results of D3?

p.4252 l. 20: I do not see an advantage in using anomalies in Figure 5 – please explain how we get additional information from the lowest plot compared to the middle plot.

p.4254 l. 2-9: paragraph is unclear, please rephrase

p.4254 l. 3: what are relative neutrons?

p.4254 l. 13-14: why use the mean difference instead of the RMSE of D1 and D3 and compare both of these to crop height?

p.4254 l. 18-20: unclear – needs to be explained in the methods section and results need to be shown

p.4254 l. 23- p.4255 l. 4: this should be explained in the methods section

p.4255 l. 5-6: to compare neutrons vs neutrons? Unclear, please rephrase.

p.4256 l. 20: etc.? please elaborate

p.4257l. 5-17: these 4 take home messages are all badly phrased and thus hardly understandable

Table A1: please clarify if you are calculating the RMSE indeed for the entire period or separately for sunflower and rye. If you are calculating it for the entire period – why do you change the procedure for the data in Figure 3?

Figure 3: legend for the colors is missing

Figure 5: why is the CRS overestimating soil moisture in the second half of June 2011? Axis labels are too small. In what way is the calculation of the anomalies helpful in this case?

Figure 6: what calibration is used here?

Figure 7: in the methods you were talking about daily measurements of crop height – in this plot the measurement intervals are longer – why?

Technical Corrections:

p. 4238, l. 4: Better write '...applicability of cosmic-ray...' p. 4238, l. 7: '...ways of integrating...' p. 4238, l. 14: '...on the other hand, the CRS signal...' p. 4238, l. 19: '...spatio-temporal...' p. 4239, l. 15: '...estimations of both snow water equivalent...'

p. 4239, l. 25: ...which better describes the...' p. 4240, l. 6: Do you mean 'bound water' instead of 'bounded water'? I will stop here because there are just too many errors. You need to carefully review grammar, spelling, style and structure of this manuscript as it is very frustrating to read in its current state.

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