Response to Anonymous Referee #2

We greatly appreciate your time for reviewing the manuscript. In the following letter we have provided specific responses and documentation how reviewer' comments will be addressed in the revised manuscript.

General comments

The presented study of Rivera Villarreyes et al. (2013) is focussing on a calibration approach of cosmic ray neutron sensing for two different crop types. They suggest three calibration schemes of the Desilets equation (Desilets et al., 2010). In a second step they present an improvement to estimate the penetration depth with four different schemes. One of the important take home messages is the influence of vegetation pattern on the cosmic ray signal.
The manuscript needs improvement in different directions. The story line is not clear.
It is hard to understand the intention. The different chapters are not clearly organised.
Information which has to be presented in the study site description is presented in the discussion. The material and methods block needs more continuity. They jump from the soil moisture estimation to the penetration depth continue with soil moisture and go back to the penetration depth. Results and discussion should be separated. The presentation of the observed vegetation patterns has to be extended. Only vegetation height is shown, variability is neither mentioned, nor any other measure like biomass, coverage or LAI. The study site needs more explanation. The soil is only described as a homogeneous sandy soil without any facts of variability in any soil physics except texture. They do not present that they are able to capture the true soil variability in a radius of 600 m around the probe with the installed soil moisture profiles. Only two field campaigns were conducted to prove and then only the top soil moisture was taken into account. The presented calibration procedure is only valuable for specified vegetation periods where the changes in the vegetation patterns are low. It involves a lot of parameter sets (for each vegetation period) and therefore increases in uncertainty.
Compared to the procedure of Franz et al. (2013) which is not even taken into account the presented method does not look straight forward and transferable. Most of the graphics are unclear and not helpful. Some parts of the results chapter is more a discussion then the analysis of the calibration. Scientific English has to be improved.
The terminology of the three calibration approaches in chapter 2.3.2 is misleading as they call them fully empirical, semi-empirical and N0-calibration. They are all empirical.
It would be better to call them three-parameter-calibration scheme, Deidri model with factor and a one parameter calibration scheme. In none of their procedures they take vegetation into account which should have an influence. Why do they not present a sensitivity analysis of the complete Deidri model instead of finding best fit of the presented three schemes? Chapter 2.3.3 is unclear in the current form. What do they want to present? The interaction of the calibration approaches and the penetration depth procedures are not well formulated and hard to follow in the text.

RESPONSE:
Based on your major points, we would like to clarify the following:

- We will improve story line claying main message of manuscript: (i) calibration approaches and (ii) vegetation correction approach directly on neutron counts.
- Materials and methods will be organized according to reviewer suggestions and specific comments below.
- Yes, we only measured crop height. We want to verify the length and position of growing stages only, which are well known in common databases (e.g. FAO). Moreover, calibration approach and neutron correction (in revised manuscript) do not depend on values of other crop measures.
- Complementing current information of soil texture, we will add new measurements of soil properties.
- We will provide an extended discussion of pros and contra of calibration schemes.
- The explanation of relation between attenuated neutrons and vegetation will be extended in revised manuscript.
- We did not use Franz' procedure (2013) because (i) we understand vegetation influence by local calibrations, (ii) drawback in requiring all hydrogen pools and other chemical composition, (iii) we will provide a vegetation correction directly applied on neutron counts and not on soil moisture.
- Regarding to the English quality, before publication of manuscript in HESSD, authors sent it to the English proof-reading of Copernicus editorial office for further improvements. We will re-send manuscript for second revision in this revised version.
- We will propose other more-descriptive names for calibration approaches.

Specific comments

P 4240 L 22: Add dominating geology, meteorological forcing as mean temperature, ET, precipitation, is there groundwater influence or not, what is the agricultural practice on the study site, is there an effect on soil properties.
RESPONSE: We will provide a detailed description of these entire in revised version.

P 4241 L 519-20: Add a citation.
RESPONSE: Yes, we will add it.

P 4242, L 11-12: Which data was used from the FAO?
RESPONSE: This sentence is reformulated as follows: "Moreover, length of growing stages of sunflower and winter rye defined by crop height was verified from data base from the Food and Agriculture Organization (FAO)".

P 4243 L 12: Delete the C in front of the theta
RESPONSE: Yes, we will delete it.

P 4243 L 13: Comment here the importance of lattice water for the specific study site. Is the parameter important in the dominating geology? Franz et al. (2013) include as well organic content, comment also on that.
RESPONSE: Lattice water is only relevant for calculation of penetration depth. In the case of CRS calibration, lattice water is already included in local calibrations. Moreover, we will complement this information as follows:

"Dominant geology in Bornim site is quartz sand formed in the quaternary age, in concordance to measurements of soil texture. Values of lattice water tends to be more relevant in soil types dominated by clay. Lattice water was 0.012 g/g, which is relative low compared to range in COSMOS sites (Zreda et al 2012)".

4243 L 22: How is atmospheric water vapour correction taken into account?
RESPONSE: Correction factor was computed by following the recommendation of Roselem et al (2013). A correction factor is needed in case of large deviation of actual air density in respect to a reference value (mean or dry conditions). In our case, this variability was minimal; therefore, correction factor was negligible.

P 4244 L 5: Change variable to parameter.
RESPONSE: Yes, we will change this.

L 4245 L 4: Scenario is misleading, procedure would be better.
RESPONSE: Yes, we will change this term.

P 4246 L 14: The homogeneity of soils has to be presented with hard data.
RESPONSE: We will provide more data in methodology section.

P 4247-2448 L 9-18: Most of that block can be moved to study site description. Texture analysis does not alone describe the homogeneity of a soil. What is the structure of bulk density? Organic content which is twice mentioned in the results part (P 4250 L 15 and P 4253 L 19) should be discussed. What is the layering structure of the geology, water repellent effects in the glacial shaped landscape where the study site is located can have an influence on the soil moisture pattern, what is the dominating soil type, etc. The histogram should be presented. With two campaigns at the surface it is a hard to judge, whether they can represent the mean soil moisture in profiles.
RESPONSE: Dominant geology in experimental site is quartz sand. There is no layering in structure of geology. Soil profile is classified as sandy profile in geological maps. Soil classification from national maps is also sand. From our texture analysis, sand class was the dominant inside footprint. Organic matter and lattice water show a low degree of variability. We will clarify all these information in the revised manuscript and present additional data on this.

P 4247 L 24-26: Unclear, please give additional information how that was conducted and how the structure of the soil was effected by the agricultural processing (ploughing etc.) and to what degree the structure is comparable to the current state.
RESPONSE: We will provide information about sampling campaigns as follows:

"The representativeness of five FDR locations selected for this study was also verified against two soil moisture campaigns in 121 near-surface locations (three replicates at each location) within the CRS footprint (Fig. 1). Campaigns were carried out in August 10^{th} and 19^{th} 2010. Soil moisture was sample with a mobile FDR sensor connected to a HH2 Moisture Meter (Delta-T Devices Ltd., Cambridge, UK) and same calibration of FDR profiles".

During the corn period, no tillage was carried out since we measured at the very end of the season. In the case of monitoring in seasons of sunflower and winter rye, FDR sensors were installed shortly after sowing and uninstalled before harvesting. During this period, there were not tractor activities. We will include this information in methodology.

P 4248 L 15: Why didn't they use the specific density of the sample instead of the mean value? In the described methodology they lose information of each unique soil sample. Which grain density was used?
RESPONSE: Yes, this is sentence is not well structure. In revised manuscript will be as "Volumetric soil moisture from soil cores was calculated from gravimetric soil moisture multiplied by its corresponding bulk density, which present an average of about 1.40 g cm^{-3}".
Additionally, we will present information about soil properties in depth.

P 4249 L 2-28: Present how much variance in the observed data can be represented with the procedure. That paragraph can be shortened. Use a table.
RESPONSE: Yes, we will present the information in a new table and shorten the paragraph. For variance see response to earlier comments.

P4250 2-3: Last sentence has to be deleted.
RESPONSE: We believe this sentence provides important clarifications of main difference between calibration approaches. The fact that three-parameter fitting approach provides better soil moisture measurements than single-parameter fitting; it is an issue of optimization. Moreover, it is clear to emphasize that a drawback of three-parameter approach is the need of more calibration data, i.e. single-day sampling approach can not be used here.

P 4254 L 18-20: Present or delete! What was the result of that modelling approach?
RESPONSE: Since we will present a vegetation correction directly on neutron counts, we will not observe benefit on including LAI model. We will delete this part.

Table 1: Bulk densities are not in the equations, delete. What is the N0 value for the first two assumptions?
RESPONSE: Yes, we will correct table caption and specific value of N0.

Table 2: Add information of variability and additional soil physics. The crop can not only be described by the average height.
RESPONSE: For our proposed calibration approach and vegetation correction, we do not need more crop information. Crop height is needed only to identify the growing stages. We will clarify this issue in revised manuscript.

Figure 5: Are the different approaches plotted or only one?
RESPONSE: In current version only best results are plotted. In revised manuscript we will also include worst calibration result, as comparison.

Figure 6: The initial state (of sunflowers or both vegetation types?) soil moisture shows a low correlation to neutrons. Comment on that in the text.
RESPONSE: Yes, this information will be added in text. Please see the response to comment P4254 L4-6 of reviewer # 1.

Figure 7: Add variance to the height.
RESPONSE: We will discuss vegetation influence on the neutron directly. This figure will be deleted in revised manuscript.

Figure 8: Why are biomass, root density and crop water content not measured? You should not "expect" you should "know". That information should be part of the analysis and not of a caption.
RESPONSE: We agree that additional measurements of above-ground biomass, root biomass and crop water content would be an interesting add-on information. However, our calibration approach requires only defining the major stages of crop development on top of the measured neutron counts. These periods are usually identified knowing length of periods and sowing date. Fortunately, information of stage length is well known in crop databases (e.g. FAO). We verify this information with measurements of crop height.
In revised manuscript, we will present a vegetation correction approach applicable directly to time series of neutrons. This follows the intended development of a specific, flexible application procedure for cosmic ray neutron sensing in farmed cropped fields under ploughing and harvesting procedures not allowing for longer-term installation of soil moisture networks and neither for intensive destructive sampling of crop parameters in the footprint.
This figure in the revised manuscript will be presented in terms of time series for a better discussion.