Response to Editor Comments

Dear Prof. Erwin Zehe as handling editor,

We greatly appreciate your time dealing with the manuscript and assessing the review comments. The issues raised will be addressed in the revised manuscript and the response letter. We want to briefly outline our responses and changes, firstly in respect to your comments, secondly to the reviewer comments.

The revised manuscript should in particular:

- Present a clear story line with research questions/hypotheses including a reproducible explanation of the different calibration approaches and employed methods (their pro's and con's);

RESPONSE:
The three reviewers recognized that the novel character of our study is the long-term application of the cosmic-ray neutron sensing to a field which is cropped with two different types of crops. Thus, we present insights of quantifying the deviation of cosmic-ray soil moisture due to the crop vegetation cover. We mainly aim for looking at different calibration approaches in respect to the vegetation dynamics in the studied cropped field, and would like to focus in a revised manuscript more on this issue and less on assessing calibration approaches in a more general way. However, we acknowledge that the selected title of manuscript may be not fully adequate for the final take-home messages (also cf. general section of reviewer # 3) and the intended slight shift of main focus. For instance, a modified title such as "Cosmic-ray neutron sensing for soil moisture in a cropped field: testing calibration approaches during a vegetation period" may better represent the research direction of our study.
Since we now would like to go one step further and suggest a correction function for the calibration to account for the vegetation dynamics, we will tailor the story line in this direction and diminish weight on side-issues.
We would like to emphasize that study does not intend to develop new ways of calibrating the cosmic-ray neutron probe, and nor to provide transferable functions for different crops, seasons and field sites. Instead, we provided three ways for calibrating the cosmic-ray neutron probe in order to demonstrate that our conclusions regarding to vegetation influence are independent on the fitting approach (cf. Figure 7 left). Revised manuscript will be re-structured in order to emphasize this research direction.

- Address scale issues/ the incompatibility of the support volumes of point measurements and the Cosmic Neutron Probe and explain how that has been bridged in your approach; any calibration approach needs to be verified in a split sampling;

RESPONSE:
We do not intend to present an upscaling approach or scale transfer, but the cosmic ray neutron sensing opens access to another scale than FDR/TDR and soil cores. Since it targets a different quantity, which is at the end a water mass stored in the upper part of

soil on scale of hectares, it should be less seen from a perspective of a heterogeneous soil moisture distribution such as in classical soil physics, but rather from a landscape and remote sensing perspective. This water mass detected is usually transferred into soil moisture for comparison with point-measurements and link to models, in the sense of presenting a good average of the soil moisture in its considerably large footprint. Though other studies may investigate in detail how the heterogeneity of the soil moisture distribution influences the detected average soil moisture, by applying a huge network of soil moisture measurements, we follow another approach that improves the applicability specifically for cropped fields, and in a flexible way. This approach will enable an application of the method to cropped fields with no permanently fixed instrumentation, but short-term accompanying measurements that can be removed before harvest and other agricultural measures, and then easily and quickly be continued at the same or another field. We believe this approach to be valid in its own right, such as other applications emerge which are even more mobile ("roving") that use almost no direct point-soil moisture measurements in the study area.

- Discuss the meaning of a large scale average soil moisture in the light of heterogeneity/ possible trends of soil hydraulic properties within the integration volume and related trends/variability of soil moisture; What does an areal average tell us in this case?

RESPONSE:
On one hand we refer to our answer of the second comment of the editor. On the other we want to point out the following:

- We have a low variability of soil moisture measured in two field campaigns with 363 measurements each one (cf. current manuscript).
- We have a low temporal variability and good agreement between FDR soil moisture in 19 locations (Zreda et al 2012 recommended 18 locations) and 5 selected locations in current study. Here RMSE was only 0.018 m^3 m^{-3} (To be added in revised manuscript).
- Range of soil texture between surface measurements and depth measurements (down to 40 cm) are well comparable. Moreover, this trend is verified with soil maps and geological maps from the region. These points will be discussed further in revised manuscript.
- We have a low variability of organic water, lattice water and hydraulic conductivity measured inside the footprint (and a new table will be added in the revised manuscript).

-Provide exhaustive data in particular also on crop phenology and their development within the time period of investigation as well as on other influencing variables

RESPONSE:
Since we are focusing on the dynamic changes of the influence of growing vegetation on the CRS detected average soil moisture and how to compensate for it, we follow an approach based on measuring crop height. This is the standard parameter used and

measured for crop dynamics according the FAO referencing. We have no intention to develop a general biomass correction procedure to be transferable to other vegetations and biomasses, but we follow an approach that should account directly in the calibration for the (future or observed) crop dynamics in a vegetation period. In the revised manuscript we will present a function to accomplish that which can be applied with simple crop height measurement as part of the flexible approach to establish cosmic ray-neutron sensing applications in cropped field and possibly for short periods of time only at a single location.

Indeed, we highly appreciate your contribution to this study with all your constructive comments. We will submit a revised version based on review comments and yours, and according to the timing designated by editorial office.

Best regards,

On behalf of co-authors,

Carlos A. Rivera Villarreyes