Dear Reviewer:

We greatly appreciate the your time reviewing the manuscript, and have carefully taken into consideration all of the comments. In the following letter we have provided specific responses and documentation from the revised manuscript. All coauthors have agreed to the revisions. We look forward to your response and publication in HESS.

General Comments:

As suggested by the reviewer we have modified the abstract and methods section to be more informative and comprehensive. In addition we have added a new Fig. 1 that shows an example of Eq. (1) and subsequent uncertainty bounds for different counting rates. The reviewer asked that we provide uncertainty estimates in terms of pore water content instead of cph. Given the nonlinearity in Eq. (1) it is difficult to specify pore water content uncertainty. Fig. 1 now provides a way to estimate the pore water content uncertainty from the counting rate uncertainty specified in the various fitting excercises in the manuscript. Finally we have added the influence of soil organic carbon (SOC) and its associated hydrogen to the analysis. We have treated SOC similar to lattice water as suggested by *Zreda et al.* (2012). By including SOC we have further reduced the uncertainty in the analysis with an R^2 going from 0.75 in the original work to 0.79 by including SOC in the analysis.

The following are the responses to specific comments by the reviewer (in italics). Note the line numbers and figures number are from the new revised manuscript.

Reviewer 2

First of all, I would like to congratulate the authors for this great work, very interesting and new within this field. I have seen in this paper one of the best analysis with respect to soil moisture in-situ measurements, and I am sure with some improvements already on going, the results obtained with this new technique will be cited and used a lot of times in other future papers.

Nevertheless, I would like to add my comments regarding to the science quality behind this analysis and of course the validation of this technique for mosaic regions. The soil bulk density, as mentioned in Section 3, Page 10311, plays a very important role to determine accurately soil moisture, but in all the regions with forest where there is a litter layer or a thick layer of leaves, this technique nowadays does not improve the soil moisture measurements with disaggregating the effect of this litter layer with respect to other already existent ones, and also with stony soils as also mentioned in Abstract section is mot possible to get good results. Here take place multiple interactions between diverse variables involved and it is necessary to find the better choice of some of them to reach better results, more reliable and significant to provide a universal calibration function which could be used for every soil type.

Correct, estimates of soil bulk density and hydrogen in the litter layer or below ground biomass remain a challenge in forested areas. However as long as the hydrogen pools are not greatly varying with time, this method will give you the temporal dynamics of changes in system hydrogen. However, in order to convert it into mass/volume of water you will need estimates of bulk density as you have mentioned.

One important advance of this technique is that the calibration function is not a function of soil type or temperature (like TDR) but instead only hydrogen moving in an out of the support volume. Measurements of lattice water and soil organic carbon (SOC) can be readily made in the laboratory on small soil mineral samples. Estimates of above and below ground biomass, and the spatial and temporal variability of SOC remain challenging areas to accurately quantify.

Sincerely, one of the best advances of this technique was to be capable to determine soil moisture averaged over wide and extensive areas and I think is in this averaging where it is being taken a variety or mosaic of vegetation and soil types, which show at the end an averaged result of all and consequently it does not reproduce the real conditions.

The representation of soil moisture over heterogeneous areas with the cosmic-ray neutron method remains a challenging issue both experimentally and numerically. We have made some work on the modeling side and find Guassian soil moisture fields with short correlation scales (less than say 30 m) have minimal impact on the average neutron count (manuscript to be submitted to WRR very soon). However, heterogeneities with larger spatial structure approaching the footprint radius of 335 m will be more difficult to address given the nonlinear relationship between soil moisture and neutron counts (Eq. 1) when averaging heterogeneous systems.

Another of the most difficult issues and very challenging may be to improve the sensitivity to the hydrogen molecules amount just above and also just below the surface, which affects directly to the neutron counts and consequently to the effective depth of the measurement. With a varying effective depth depending on soil moisture content, the accuracy to determine properly the Volumetric Water Content (VWC) in these zones around the soil surface is not easy to be solved.

Correct, sharp soil moisture transitions near the surface are problematic given the nonlinear relationship between soil moisture and neutron counts (Eq. 1) when averaging heterogeneous systems. See Franz (2012a) for averaging of the wetting front and the nonuniqueness introduced in the relationship.

I recognize the difficulty to address this important issue and thefore the work showed in this paper is on the right track to find a function capable to describe the most soil types as possible.

And to finish just mention that the uncertainty issue, which is just the final result of the processing carried out previously, will be of course minimized if the treatment of the vegetation and organic matter (biomass) present in the soil surface layer is carried out

with a better accuracy.

L 294-297: We added the line:

"Additional experimental work on accurate determinations of bulk density at intermediate spatial scales, better quantification of above and below ground biomass and soil organic matter will help reduce the overall uncertainty in the cosmic-ray moisture measurements.

Thanks for offering this great work to the science community. Congratulations again!