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Interactive comment on "Improving Calibration and Validation of Cosmic-Ray Neutron Sensors in the Light of Spatial Sensitivity – Theory and Evidence" *by* Martin Schrön et al.

Anonymous Referee #2

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The paper by Schrön et al. (HESS-2017-148) describes development of an improved approach to calibrate cosmic-ray sensors of soil moisture. The new approach is based on the re-evaluation of the spatial sensitivity function, published by some of the same authors in 2015. The new sensitivity function shows that areas near the probe are much more important than previously thought. Therefore, the calibration methodology, and specifically the selection of sample location within the footprint, must be re-evaluated. This is the subject of this paper. The authors have found that samples should be collected closer to the probe (than previously recommended) to be more representative of the area sensed by the neutron probe. They also analyzed the contributions of different sub-areas within the footprint and concluded that proper weighting that accounts

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for spatial variations of soil moisture produces improved calibration; the improvement was assessed by comparing with independent measures of soil-moisture field, mainly obtained from distributed sensor networks, at six locations.

The overall quality of the paper is high: the conceptual aspects are clearly described, the mathematical model is sound, and its execution and comparison with field data are credible. The paper solves an important problem in the field of cosmic-ray neutron sensing of soil moisture and other moisture at the land surface. Because of these qualities, the paper deserves to be published in HESS. I have made many criticisms and suggestions for improvements. Some are regarding the conceptual model and execution, others refer to field data; yet others are editorial and serve to improve the clarity and readability of the paper. All comments, criticisms and edits are on the attached pdf file. On implementation of these suggestions the paper should be publishable in HESS.

The two main criticisms concern the assessment of soil moisture within the cosmic-ray footprint using independent means (used for calibration), and the comparison of time series of independent and cosmic-ray soil moisture (used for validation). The recommended calibration scheme calls for about half of the calibration samples to be taken inside the 20 m radius. This will over-characterize the small area (<20 m) in comparison to under-characterized wider field (>20 m). I would like to see some discussion of how these over- and under-characterization will affect the calibration. Please, see the annotated manuscript for details.

The concern about time series stems from the fact that distributed sensor data typically do not include the top 10 cm of soil. And because the top 10 cm is critical to cosmic-ray signal, particularly after a precipitation event, these data are not comparable to cosmic-ray derived soil moisture. Placing point sensors close to the surface (0-2 cm) will change your comparison between point sensors and cosmic-ray data. If these shallow depth data are not available, your conclusion regarding the comparison, and by extension regarding the calibration, suffer diminished credibility. I would like to see

an assessment of the effect of the lack of near-surface point data on the comparison. perhaps you can develop an assessment that could add to the uncertainty of the point data, and this will affect the comparison with cosmic-ray data.

In summary, I recommend this paper for HESS, but suggest many improvements that I hope the authors will implement to improve the quality of the paper. None of these are disqualifying, so the authors are free to accept or reject my suggestions.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/hess-2017-148/hess-2017-148-RC2-supplement.pdf

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