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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Investigating temporal field sampling strategies for site-specific calibration of three soil moisture – neutron intensity parameterisation methods" *by* J. Iwema et al.

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We thank the reviewer (T. Caldwell) for his time and his positive feedback on the manuscript. We address all comments in detail below:

[1] The authors of HESSd-12-2349-2015 provide guidance to suitable calibration methods for the Cosmic-Ray Neutron Sensor (aka, COSMOS). Varying neutron intensities unrelated to soil moisture (H-content in biomass, interstial clay, snow, etc.) adversely affect it. The authors assess 3 calibration methods and

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data requirements (from in situ sensors) over a range of hydro-climatologies and land cover. Since CRNS integrates over a varying depth range (p2351, L3) depending on moisture content, it doesn't appear to me that the sensors were depth-weighted by any means. How does assuming a constant depth-integration weight over the 5-, 20-, and 50-cm probe impact the variable depth integration of the CRNS? Beyond the equal horizontal weights (which may also introduce some error, p2352, l12), the depth weighting of the in-situ sensors needs more clarification. In particular, these sensors are a surrogate for actual soil sampling. The authors focus on number days very well, but don't specify how deep – since some (SR) profiles exceed 50-cm. Considering that you removed the soil organic matter and interstitial H from equation 1-2, or hydrogen content in HMF, do these data need collected (over 'x' depth) as well? Also, please add a little detail on Bogena et al. 2013 which is referenced for all the sensor depth averaging. Perhaps this is all in Bogena et al. 2013, but since mean spatial and profile water content are so important, a little more elaboration is required.
The temporal resolution and 'wetness' condition is well-defined and the manuscript is well-composed and very thorough.

Response: We thank the reviewer for his important comment. The method of Bogena et al. (2013, WRR), which we used to compute weighted average soil moisture contents as input for the modified N0 method and the HMF method does take into account depth-weighting (i.e., weight exponentially decreases with depth). To better clarify this, we propose to change this sentence in Section 2.3.1:
"We calculated depth-weighted profile average soil moisture contents with the methods proposed by Bogena et al. (2013)."

to:

"We calculated depth-weighted profile average soil moisture contents with the methods proposed by Bogena et al. (2013) to consider exponentially decreasing weights (wz) with depth:

HESSD
12, C955–C958, 2015

$w_z = 1 - e^{\frac{-z}{y}}$

and

$y = \frac{-5.8}{\ln(0.14) \times (H_p + 0.0829)}$

where z represents the measurement depth in cm and H_p represents the total below ground hydrogen pool in the respective soil layer in g H2O per cm^3. For a more detailed description of the derivation and computational implementation we refer to Bogena et al. (2013).”

Soil organic matter and lattice hydrogen were not depth weighted, instead we used arithmetic mean lattice water and soil organic matter contents of the top soil, following the approach of Baatz et al (2014), and provided directly by the COSMOS network.
We suggest adding the following sentence to the discussion:
“Explicitly taking into consideration the depth varying SOM and lattice water content could potentially improve neutron count estimates.”

[2] Line specific comments: P2351, L20: Awkward sentence: “However, fast neutron intensity is not solely dependent on soil moisture content”

Response: We thank the reviewer for notifying us of this sentence. We will change the sentence as proposed.

[3] P2352, L3: what is ‘it’?

Response: We thank the reviewer notifying this is an unclear sentence. We propose to change the sentence as follows:
“According to Desilets et al. (2010) and Zreda et al. (2012), only a single parameter (N0) needs to be calibrated. This can be achieved with a single calibration point from average soil moisture representative of the CRNS footprint. A similar approach is typically used for HMF although estimates of additional hydrogen sources are also needed (Franz et al., 2013).”

HESSD
12, C955–C958, 2015

[4] P2355, L7: it's 'coarse material', not course.
[5] P2360, L26: 'until' not 'till'

Response: We thank the reviewer for notifying us of these two errors; we have modified the wording in the manuscript.

Citations

Baatz,R., Bogena, H.R., and Hendricks Franssen, H.-J., Huisman, J.A., Qu, W., Montzka, C., and Vereecken, H.: Calibration of a catchment scale cosmic-ray probe network: a comparison of three parameterization methods, J. Hydrol., 516, 231-244, doi: 10.1016/j.jhydrol.2014.02.026, 2014.

Bogena, H. R., Huisman, J. A., Baatz, R., Hendricks Franssen, H. J., and Vereecken, H.: Accuracy of the cosmic-ray soil water content probe in humid forest ecosystems: the worst case scenario, Water Resour. Res., 49, 5778–5791, doi:10.1002/wrcr.20463, 2013.

Desilets, D., Zreda, M., and Ferré, P.A.: Nature's neutron probe: Land surface hydrology at an elusive scale with cosmic rays, Water Resour. Res., 46, W11505, doi:10.1029/2009WR008726, 2010.

Franz, T. E., Zreda, M., Rosolem, R., and Ferre, T. P. A.: A universal calibration function for determination of soil moisture with cosmic-ray neutrons, Hydrol. Earth Syst. Sci., 17, 453–460, doi:10.5194/hess-17-453-2013, 2013.

Zreda, M., Shuttleworth, W. J., Zeng, X., Zweck, C., Desilets, D., Franz, T., and Rosolem, R.: COSMOS: the COsmic-ray Soil Moisture Observing System, Hydrol. Earth Syst. Sci., 16, 4079–4099, doi:10.5194/hess-16-4079-2012, 2012.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 2349, 2015.