I am still troubled by a potential flaw in this manuscript. As I understand the work, the link between true field soil moisture and modelled comparisons has been lost, although Fig. S5 may show that this is not the case (do Fig. 5 measurements use the fitted N_0_Des or a field calibrated N_0?).

Note although this paper is about improving soil moisture (process) representation in models (the title), there is only one plot showing calibrated modelled soil moisture, and this is in the Supplementary. In the main paper, only neutron count comparisons are shown. Since both the relationship between neutron counts and soil moisture and the predicted soil moisture are both calibrated, it would seem to me that there is no longer necessarily a representation of true field soil moisture. It is noted that the authors (in previous reply) have chosen to focus on neutron count agreement, rather than soil moisture agreement; however, I would urge the authors to consider how this method can still be traced back to the absolute soil moisture measurement.

To elaborate on this point: as the authors describe, the CRNS method for field soil moisture (SM) measurement has a free calibration parameter N_0, or more specifically here N_0_Des. Through careful field calibration, normally by collection and moisture analysis of field soil samples, the value of N_0_Des is determined. This provides the crucial link or traceability of the measured neutron counts to soil moisture content – the quantity which hydrologists are actually interested in knowing.

However, in this paper, the field calibration value of N_0_Des is not used. Instead as part of the model calibration period (line 292) the N_0_Des is optimised – presumably by minimising the neutron count rate or soil moisture error of the model (it is not stated what objective function was used). This model calibrated N_0_Des will be different to the field calibration, giving different soil moisture content for a given neutron count – thus the true site-specific calibration of neutron counts to soil moisture has been lost. Whilst the calibrated model may have better agreement with the observed neutron counts, the model output calibrated soil moisture does not necessarily have a similar improvement i.e. the soil moisture could be biased high or low, and that bias accounted for in terms of neutron counts by the model calibrated N_0_Des.

Seeing Fig. S5, I actually do not think this flaw really exists – but the detail of the N_0 model calibration versus soil moisture calibration needs to be clearer to explain how this potential issue has been dealt with. The authors should justify their approach of a model calibrated N_0 versus using the value already known from site specific field calibration of the CRNS. And it may be of value to compare these.

Specifically:

Line 303 “Estimated values of N_0_Des and N_0_COSMIC obtained in our study are close to optimal values” – how do you know that? What are the optimal values? And the inference drawn is not sound – model simulation of dry conditions is not a prerequisite to obtaining accurate N_0 values.

Results – Fig. 5 Also show plots of SWC (as per field calibration – observations) and calibrated modelled SWC.

Discussion – I would question the soundness of discussing model performance, when it appears that neutron count comparisons rather than SWC have been calibrated. As the authors have chosen to present neutron count data, then they need to be careful as to what is claimed with regard to soil moisture modelling, or to provide evidence to support those claims.

Line 440 “ …improved not only soil moisture estimation” – NO improvement in soil moisture estimation is shown in the main paper!

Conclusion – Line 507 …evaluation with soil moisture observations has not been shown.

Several statements in the conclusion are not supported by the paper (at least not without digging into Supplementary material) e.g. Line 525 “improved the soil moisture performance of the model”