

Overview

The paper describes the simulation neutron count rates using a gridded hydrological model, which estimates soil water content in different depth layers. The simulated counts are compared with CRNS neutron counts to optimise the model (mHM) calibration. This approach addresses the issue of the variable measurement depth of CRNS. In simulating neutron counts, published models are used such as COSMIC, or the CRNS neutron count to soil moisture calibration function is inverted. However, these relationships are further fitted through optimisation of the N_0 parameter, and different published schemes for vertical soil moisture content weighting are tested. Other mHM parameters are also optimised, but how this is done and in what order, is not explicitly described. Which parameters are optimised is only shown in the supplementary information, and the results and discussion do not cover these parameters.

The motivation of this work is valid, but not very clearly expressed in a long introduction which should be more focused. Only at line 81 is the issue of measurement depth introduced, whilst this is a key part of this work. Other specific issues in the presentation (see below), make the reader question the validity of the work, and I doubt that the study could be reproduced from the description. There is further concern whether the methods are suitable to meet the objectives of the paper, for example there simpler ways to evaluate the depth weighting, without complicating factors such as a gridded model representation of a site (which could be better modelled as a single point).

Some of the Discussion is also unfocussed, and reverts to discussing other work, without bringing much insight into this study. There is no discussion on the optimisation of hydraulic parameters or PTFs, nor how this might improve model performance at other locations e.g. how can the results be transferred to grids without CRNS observations?

The manuscript needs to be revised to be better focused, clearer to the reader, and provide sufficient detail in the Method to be reproducible. The results and discussion need to cover the other model parameters optimised, whereas currently only CRNS parameters and a rooting parameter are mentioned, as though they are the only influences on the results. Also, there is much claim of improvements in modelled soil moisture, when most of the plots only show neutron count comparisons. It is really unclear as to how much improvement comes from better model parameterisation of the soils, and how much is due to changing the relationship between neutron counts and soil moisture – I even wonder if the observations are being calibrated to fit the model? How do the newly fitted values of N_0 compare with those fitted by site soil sampling calibrations?

How did you optimise N_0 before you optimised other mHM parameters? A schematic of your methodology may help, especially to show the order of optimisation – before optimisation, neither the simulated counts are true (or best estimate), nor the modelled soil moisture (SM) layers. Does your method iterate so these parameter sets both improve together?

Specific Points

Line 52 by this point or earlier you should say why there could be an issue with depth averaging.

Line 70 delete 'eventually'

Line 75 still no intro as to the motivation to do this - rather than use the derived SM!

Line 86still not clear what is the objective of this study?

Line 89 If the objective is a technical comparison of methods, then why do this at grid scale, not a point scale, actually at the CRNS station? This may have complicating factors e.g. mixed land cover, soils and topography modelled across a grid cell.

Line 99 there seems to be an implicit assumption that working with simulated counts is better than using CRNS derived SM - did you test this?

Lines 102-3 does this mean different land cover in grid or between grid cells?

Line 108 homogeneous at the CRNS hectare scale, but not at 1km scale! - see photo of Grosses Burch. Please be more specific – and how might in-grid heterogeneity affect optimisation?

Line 115 Are these seasonal biomass fluctuations included in the CRNS count simulation?

Line 159-60 ‘the sensitivity to the highest...’ re-phrase, this is not clear.

Line 170 delete ‘time constant’

Lines 183-87 it may make sense to use grid averages for mHM, but this complicates the evaluation of the methods – how representative is the CRNS station of the wider grid properties? If the station is not representative of the grid, then inappropriate parameter changes are forced to match soil moisture or CRNS counts to soil properties that do not match the CRNS site.

Line 187 How can varying N_0 properly account for biomass changes? Biomass is dynamic in time, whilst N_0 is constant in time?

Line 212 change ‘neutrons’ to neutron flux or count rate.

Eq. 9 is bulk density here the same as Eq. 1? (a different undefined symbol is used here and in Eq. 10)

Line 238 these symbols are not in Eq.14 ? - what are L_{30} & L_{31} ?

Line 257 Table 2 shows model performance measures, not model parameters and their ranges - please add table of model parameters optimised. (it is in supplementary)

Line 269 ...presentation of results is confusing, as it does not show hydraulic parameters (only refers to Table S1). Plots and tables only show CRNS parameters.

Fig.4 – add units (...are these counts per hour?)

Line 301 This gives the impression that what has been done here is to optimise neutron count match, by varying some model parameters, especially N_0 , and some root depth parametersthere could be an issue that whilst counts may agree well, systematic bias in SM could be compensated for by varying N_0 ; i.e. better efficiency in simulating neutron counts may not necessarily lead to better efficiency in SM modelling.

Section 3.2, Fig. 5 & Fig.6 – should show these also as CRNS SM plots - as the non-linear counts to SM hides the magnitude of discrepancies.

Line 410 – this study does not assess the absolute soil water quantity (most results are presented as neutron counts).

Lines 412-13 'Incorporating CRNS data...' this statement is untrue and does not makes sense.

Line 430 this is misleading as it implies data assimilation, whereas neutron data is not incorporated, it is simulated by mHM and then compared with observed counts.

Line 450 'After optimizing the soil hydraulic properties...' this is not properly described in the method – is this done after CRNS parameters are optimised or at the same time in some form of iteration? How did you do this?

Fig.9 – surely belongs in Results?