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Comment on hess-2021-276

Anonymous Referee #2

Referee comment on "Depth to water table correction for initial carbon-14 activities in groundwater mean residence time estimation" by Dylan J. Irvine et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-276-RC2, 2021

General comments

This paper uses literature values of unsaturated zone ^{14}C activities to develop a depth to water (DTW) correction for initial ^{14}C values for groundwater dating. Not all previous studies have assumed that the unsaturated zone is in equilibrium with the atmosphere, but many have. In these cases, the correction indicated by the equation can be substantial (corrected mean residence times (MRTs) can be thousands of years younger than the uncorrected MRTs). These effects are well known, as attested by the 14 studies used to develop the DTW correction, but the contribution here is the development of the correction equation, which will be easy and useful for others to adopt.

Logically, the DTW in the recharge area has the most relevance to the correction required, not the DTW where the sample was collected. Using the DTW from the sample location (as in this paper) is a compromise made for convenience. The paper makes the implicit assumption that only the residence time in the saturated zone is of interest. Time spent passing through the unsaturated zone in the recharge zone presumably is assumed to be negligible or of no interest (which of these is not specified as this issue is not mentioned in the paper).

The authors have adopted a very simplified MRT estimation procedure, which they label "conventional". It is hardly conventional, since it ignores (1) the recent history of ^{14}C activity in the atmosphere due to nuclear weapons testing (instead they assume a uniform atmospheric activity), (2) the input of ^{14}C-free carbon from the aquifer matrix (i.e. they assume q = 1), and (3) groundwater dispersion producing a distribution of residence times in the sample (in effect assuming piston flow). I think it could be described better as "simplified". However, as an exercise to illustrate the application of the correction equation it is reasonable.

The paper is well organised and succinct, but possibly too succinct in parts making it unnecessarily difficult to understand. (e.g. The caption of Fig. 6 is very unhelpful. The symbol A_0 from the caption is not used in the text.) However, the paper is generally clearly written with few technical or detail corrections needed. It is suitable for the journal and has no unnecessary or overlong sections. The references are appropriate. The data set is sufficient to support the discussion and conclusions. Title and abstract are satisfactory. I think the paper should be published after minor revision.

Specific comments

L124-125. Not sure what this sentence means. "However, owing to the relatively small sample size, the data was included in the fitting process independent of the year in which it was collected." Does this mean that no account was taken of the actual ^{14}C input function?

L134-139. I would like to see the simplifying assumptions in itemised form (1, 2, 3)