General Comment

The authors report an impressive new synthesis of speleothem U-Th ages from the British Isles, and use this to focus on a comparison between last glacial ice sheet location and the speleothem growth. It is a very valuable contribution to the literature.

We appreciate the suggestions of the reviewer and have used their constructive comments to improve our work. Please find our responses to the comments in the attached PDF, highlighted in blue. For our responses attached we use line numbers pertaining to the updated manuscript.

Specific Comments

My questions to the authors largely relate to asking for more methodological detail so that the reader can reproduce the analyses and assess the certainty to which a speleothem U-Th age can be correctly attributed to the bins in section 4.2 'Spatial Distribution of Speleothem Growth'.

Line 98. Should the published sources of the compiled ages be cited somewhere e.g. a summary table by region? I see that the Figshare file does have complete or partial references, but that is separate from this document.

We agree such table would be useful for future researchers. We now include a full reference list containing details of all studies cited in Data File 1 in the Appendix to this manuscript (Appendix B, Lines 587-770).

On lines 103-109. The authors state that they have chosen to use the published corrected U-Th ages, with justifications given. Some dates were rejected (line 106). So that future researchers could reproduce and expand on this work, please specify the criterion used for rejection of ages.

Our criteria were very simple: We remove any samples without dates, or with infinite ages, or infinite age uncertainties (or combinations of these parameters). We have clarified this in the updated manuscript (L106-107):

"When published, the age corrected for initial ^{230}Th was used, with any samples without dates, with infinite dates or infinite uncertainties removed from the analysis."

On line 107 it is stated that where uncertainties were not provided, the average was used (depending on analysis method). Was the age also taken into consideration e.g. as written, does this likely underestimate the uncertainty for older samples, and overestimate it for younger samples, and underestimate the uncertainty for samples that are detritally contaminated. Does the inclusion of these samples have an undue influence on the overall result?

The average uncertainty values used are percentages, and so increase or decrease relatively with the absolute age of the sample. For example, an ASU date of 50 ka would be assumed to have a ±8.8 kyr uncertainty (using the average ASU uncertainty of 17.65% of the absolute age). For another ASU date, but with an age of 250 ka, the uncertainty thus would be ±44.1 kyr.

As such, we believe there is little chance of the inclusion of these samples impacting the overall reconstruction.

Lines 123-150. Could the authors provide more detail on the pdf method, noting that it is 'following Scroxton et al (2016)' but that publication might not be accessible to all. In particular, could more information be provided on the calculation of the z-scores shown in Figure 2. Did

the authors generate '10,000 synthetic ages .... calculated from the same exponential relationship to determine the predicted variation through time caused by chance' (quoted from Scroxton et al 2016).

We now include more information on the specific approach used here (L148-154):

"For this, we fit an exponential function to the dataset of age versus frequency ($y = 13.388e^{-0.009x}$). Then, for each point in time we subtracted the expected value (i.e if the function fitted the data perfectly) from the observed value, thereby removing the underlying 'natural attrition' trend that reduces the height (depth) of peaks (troughs) with time to allow for better comparison of relative peak heights. These values are then converted to standard scores (z-scores) to allow for the variability to be more easily visualised."

However, we did not generate 10,000 synthetic ages. As removal of an exponential function from the dataset is a simple subtraction of the expected value if the function represents variability of 100% of the data, we do not feel the need to consider synthetic ages here.

Furthermore, as the Scroxton et al. paper demonstrated, there is no evidence that the removal of the exponential function resulted in a random dataset.

Section 4.2.1. Would the authors consider including some expert opinion on the quality of some of the critical sites that are considered in this section. For example, Crag Cave appears to be very important when comparing the timing of the ice sheet in the west of Ireland, but how reliable are those dates? I went to look at the supplemental datafile to see if one estimate of reliability, the $^{230}Th/^{232}Th$ in the speleothem, had been compiled, and that is not the case. However, I had access to the original publication (Fankhauser et al 2016, which might be paywalled for others) and could check that these speleothems had precise dates with very low detrital Th contamination. I would suggest that this would be useful information to convey in the text, and similarly for any other sites and samples that are critical to the interpretations made in section 4.

This section does indeed lean heavily on the data from Crag Cave. As mentioned by the reviewer, the dates from this cave are very high quality and we consider this site suitable for establishing the chronology of ice sheet dynamics, because detrital contamination is low, U content is high, and so the ages are considered highly reliable. As such, we now highlight this fact in the text (L277).

No widely agreed, objective framework for judging where a line can be drawn in terms of "quality" is available in the literature as far as we are aware. While we could create such a framework ourselves, that would represent a significant expansion of the scope of this study. Consequently, as discussed in our reply to Reviewer 2, for the purpose of this paper we presume that data quality was audited at the point of peer review of original studies. The logical next step for the research following this paper will require a redating programme which includes all the existing data being brought into a common calibration framework as recommended by Reviewer 2. This is the logical point to consider establishing a "quality" framework to determine which dates are taken on, and which need to be re-done.

Lines 395-406. With apologies for the self-citation, a comment that Caseldine et al. (2008) report oak pollen in speleothems from the Yorkshire Dales well into this time period, which would agree with this interpretation.

We appreciate the suggestion and include the reference in the updated work (L405-406):

“Based on the speleothem data, an extensive ice sheet did not cover the British Isles between 70 and 60 ka. This is a conclusion supported by the reporting of oak pollen in speleothems from the Yorkshire Dales at this time (Caseldine et al., 2008). However, these pollen grains may have been reworked from older peat soils in the region deposited during the last interglacial. Our data suggest regional ice sheets may have been present in Scotland and northern Ireland (Fig. 9A).”

References

Caseldine, C.J., McGarry, S.F., Baker, A., Hawkesworth, C. and Smart, P.L.: Late Quaternary speleothem pollen in the British Isles. *Journal of Quaternary Science*, 23, 193-200, https://doi.org/10.1002/jqs.1121, 2008.

Fankhauser, A., McDermott, F., and Fleitmann, D.: Episodic speleothem deposition tracks the terrestrial impact of millennial-scale last glacial climate variability in SW Ireland, Quat. Sci. Rev., 152, 104–117, https://doi.org/10.1016/j.quascirev.2016.09.019, 2016.

Scroxton, N., Gagan, M. K., Dunbar, G. B., Ayliffe, L. K., Hantoro, W. S., Shen, C. C., Hellstrom, J. C., Zhao, J. X., Cheng, H., Edwards, R. L., Sun, H., and Rifai, H.: Natural attrition and growth frequency variations of stalagmites in southwest Sulawesi over the past 530,000 years, Palaeogeogr. Palaeoclimatol. Palaeoecol., 441, 823–833, https://doi.org/10.1016/j.palaeo.2015.10.030, 2016.