Dear Referee #2, we thank you a lot for very constructive suggestions. In the following we response (in bold) to all of your comments (in italics).

The manuscript presents a considerable effort the authors put into transferring the previously obtained chronology for Lake Holzmaar to newly recovered sediment cores. The chronology for Lake Holzmaar is a unique one, with high resolution, based on varve counting, radiocarbon and isotope measurements. The authors carefully evaluate the reliability and accuracy of all the results, and this is one of the strongest points of this work.

The progress presented by this manuscript concerns testing four different approaches to build chronology for HZM19 record in a quantitative way – concerning the precision, accuracy, and comparison with other records for distinct events, like tephra layers and biozone boundaries. Hardly ever this kind of approach is published, and typically only one, "the best" or "the chosen" age-depth model is presented in publications. Usually there is no space to discuss the reasons behind the choice and address questions of age-depth model methodology in papers focusing on proxy-interpretation. As such, I think "Geochronology" is the right journal to publish this kind of study. This manuscript can also be regarded as a guide to future research teams which may face similar challenge in the future.

Many thanks for these motivating words. We appreciate your opinion very much and agree that methodological studies are quite rare and up to know no best approach to follow has been published. We are convinced that this will change in upcoming years and think that our study will contribute to this development.

The authors preformed the modelling with use of Bacon code - the modern, but well-established tool for Bayesian age-depth modelling. They proved an excellent knowledge and know-how about using the prior information in a process of age-depth modelling, which I know from my experience is not a trivial task. On the other hand, "playing" with priors may sometimes be used in an inappropriate way, e.g. to get the modelled age matching some expectations or get unrealistic precision, but here the authors convinced me they set the parameters to realistic and justified values.

The exhaustive Introduction provides a valuable and complete context of Lake Holzmaar chronology challenges and improvements. Discussion of the results is well-balanced, and based on scientific evidence, also taking into consideration the previously obtained data, with appropriate references. Some minor issues I address in "Specific comments".

Thank you for this nice feedback. We agree that the settings using Bacon can be too difficult or incomprehensible for beginners in this field. However, they are very useful as soon as comprehended to a certain degree. Studies like ours might also help Bacon beginners to understand the different effects of parameter settings and what might be best for their own case study.

The manuscript follows the classical structure (introduction-methods-results-discussion-conclusion), which is appropriate and clear. Some of the figures and all the tables are presented in Appendix, which is fine, although the Fig. A3 is cited 16 times (!) in the manuscript text, and I suggest moving it to the core of the paper. The quality of figures and tables is good, I have some minor remarks – see technical part of the review.

In my non-native-speaker opinion the language reads fluently.

Yes, we completely agree that Figure A3 should be shifted into the manuscript. We will implement it as Figure 5 into the manuscript.

Pages 13-14

The ages derived from of 137Cs peaks are clear, I have no doubts about it, but why the slump, clearly present in 210Pb and lithology, is not demonstrated in 137Cs data? If I imagine cutting the slump section out of the 137Cs profile, it would't look as nicely monotonous as it is now. Do authors have any thoughts on that?

We apologize for making this point not clear enough. Here is our answer:

The question why the slump is not clearly demonstrated in Cs-137 activity is difficult to answer. At this section, very slow decrease in Cs-137 activity towards the top is observed. After removing the slump from the profile, there will be a slight shift to lower values but similar variations are observed below the slump section as well (between 60 and 35 cm sediment depth, see Fig. 3). It is impossible to indicate a direct reason for these shifts because small-scale incidental slumps caused by artificial disturbance may produce random variability in the Cs-137 profile.

Generally, the Cs-137 profile is smooth lacking sharp peaks, which very precisely indicates two chronostratigraphic markers, i.e. 1963 and 1986. However, there are blurry peaks, which can be interpreted as chronostratigraphic information. The reasons for this blurring may be high sedimentation rates at the coring location. Additionally, there is substantial contribution of horizontal replacements of sediments in the surface section due to redeposition caused by drifting of the monitoring buoy for meteorological data anchored in the central part of the lake. This buoy was installed in 1994 and removed from the lake in 2016. We know that several times the buoy drifted almost to the lake shore due to very strong winds. Displacement of the heavy anchor must have caused sediment resuspension and disturbances of surface sediments at the lake bottom.

Page 15

In line 377 authors state they excluded two 14C results (HZM-46 and HZM-10.1) from a list of marker layers, due to "inconsistencies in documentation". As such I would expect they are not included in any discussion and conclusion, but then in line 391 HZM-46 is referenced to – I suggest to leave the depth info only in line 391.

We agree with this suggestion and changed the text accordingly referring only to the depth value in line 391.

Page 18 Line 465-466.

I wonder about the reasons for a high noise in Model C, do the authors have some explanation for this observation? My guess would be lot of data with high density per core length, and relatively small uncertainties.

Thank you for this question. The instability of the MCMC iterations in Model C must have to do with the implementation of marker layers with normally distributed ages. We assumed that the implementation would have a positive effect on the stability of the model, but we observed the opposite. The approach seems to increase the accuracy of the non-radiocarbon dated depths with unequal jumps from these depths to the radiocarbon-dated depths, which are not directly visible in the output plot. Very high noise in iterations is normally observed, when the model calculates very different ages for each iteration. The differences have to be smaller scaled. We cannot add further explanations here and agree with your idea of high density per core length and small uncertainties of the input data.

Page 19, lines 495-499

Anchoring of the Section 3 was first mentioned in lines 289-290, here the explanation is provided plus reference to Fig. A4. Honestly, I was not able to understand the reason and way to sum the probabilities for four completely different radiocarbon results. How the ages of HZM5.3, HZM6.1 and HZM7 were shifted to form the PDFs presented in Fig. A4A? Please clarify this part of calculations. Was the age of HZM4.3 not sufficient to anchor the Section 3?

We agree with the need for a better explanation here and apologize for unclear formulation. For model D we basically followed the approach by Bonk et al., 2021. When we tried to transfer their method to our study, we struggled at the same part and had to contact the authors to clarify their approach of connecting the varve chronology part to the Bayesian model part. After further explanation by them, we were able to apply their approach. First, we provide more details to the calculation, then explain why we prefer this approach and finally how we implement a better explanation into the manuscript.

What can be seen in Figure A4A are not shifted radiocarbon ages. The x-axis refers to each tested anchor for the varve chronology in section 3 (within the age range of HZM-4.3), while the y-axis documents which probability level of each single radiocarbon age is matched if the varve chronology is anchored at age x. To find the best position along x, we simply summed all the different matched probabilities for each radiocarbon age to obtain the sum for each anchor shift along x (black line). To summarize, Figure A4A only shows, which probabilities of the calibrated radiocarbon ages are matched when we shift the anchor along the HZM-4.3 age range.

We are sure that this approach leads to the best result, as it updates the varve chronology in section 3, while considering the latest calibration curve. Furthermore, the calibrated median age of HZM-4.3 (5409 +- 95 cal. BP) is slightly younger than the basal age of the model calculated in section 2 (5419 +- 165 cal. BP), whereas they agree within their age ranges. The same issue occurs with the original VT-99 age of HZM-4.3 (5389 +- 178). By accepting the calculated anchor of 5450 cal. BP, we increase the gap between section 2 and 3, but can provide an age model without inverse age-depth relationships and at the same time decrease the gap between sections 3 and 4 (10.578 to 10.663 cal. BP)

To make this point clearer for the readership of the manuscript, we implemented following changes: We changed:

1) **the x-axis title of Figure A4A to “Tested anchor age (Age cal yr BP)”.**
2) **the figure caption to: “Figure A4: Calculations for the floating VT-99 chronology of Model D, section 3. A: Calculation of the anchoring age for the varve chronology based on matched and summed calibrated probability density function values of all radiocarbon samples within this section. The maximum summed probability occurs at an anchor age of 5450 cal BP. B: Original VT-99 (black) vs. floating VT-99 (+65 years, red dotted line?) with calibrated radiocarbon samples vs. depth.**

Page 21

If the age of LST is implemented as a marker (as stated in line 530) then it should not be derived from the model (as in line 531). I suggest deleting “and LST” in line 531 or rephrasing this sentence, and still the following paragraph discussing the interval between UMT and LST is valid.

Similar conclusion is provided on page 24, line 615 – please avoid circular reasoning

We agree and adapted your suggestion to delete "and LST" from line 531 and 615.

Page 22

I have a feeling the whole presentation on YD boundaries and duration, and comparison with other records, would benefit from some graphical illustration in addition to numbers cited in text and given in Table A6. Please consider adding such plot.

We agree and implemented the following figure into the manuscript:

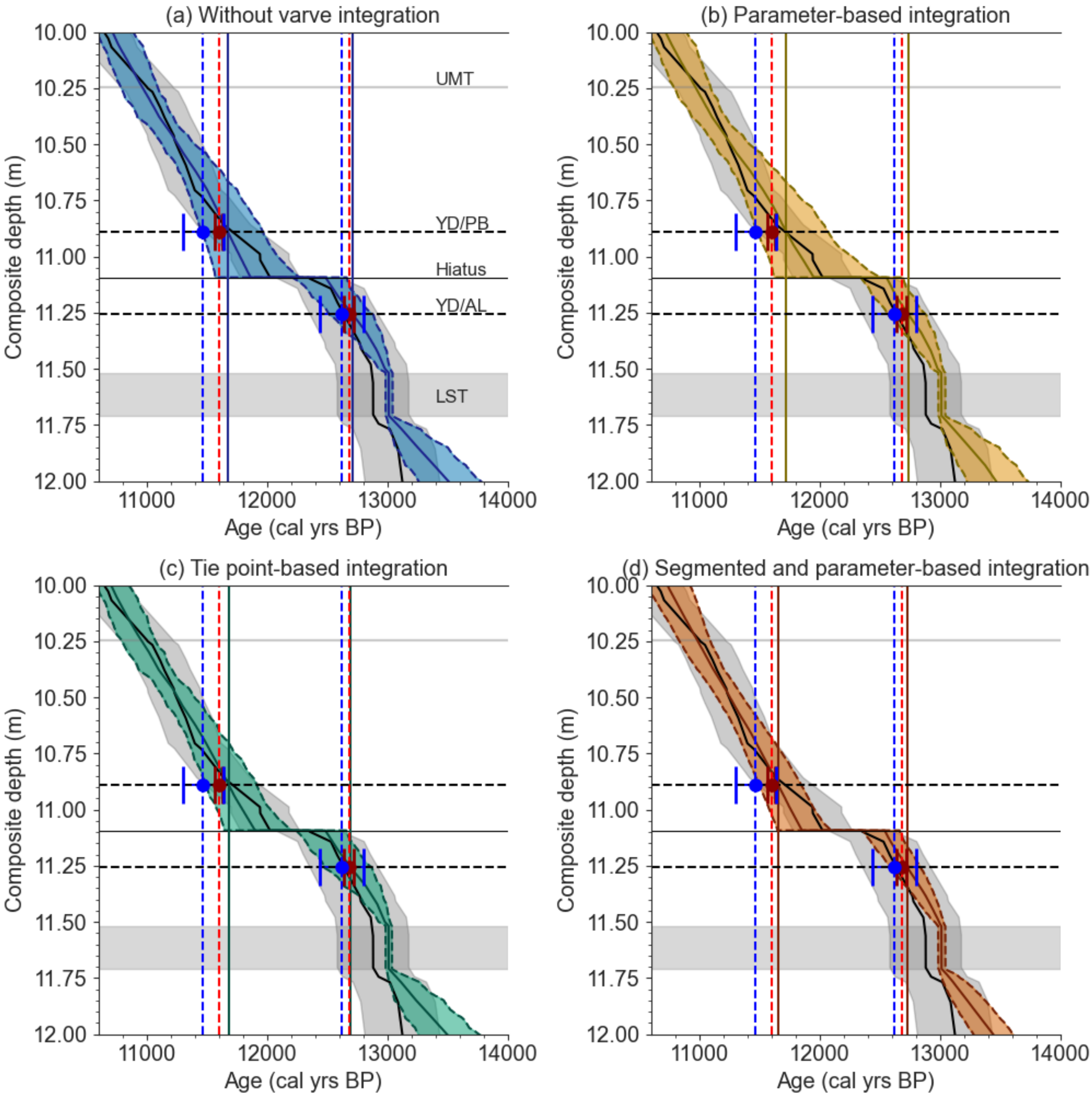

Figure A5: Close-up plots for the Lateglacial / Early Holocene transition for Model A, B, C and D with VT-99 mean age (black solid line) and error (shaded in gray) for comparison. Horizontal lines as labelled in (a). Vertical lines refer to the Younger Dryas transitions for each Model (solid lines), while dotted lines refer to mean ages derived by different sites (Lake Gosciaz in blue: Bonk et al.*, 2021; Meerfelder Maar in red: Brauer* et al.*, 1999).*

Technical corrections

Line 10

Abstract, first line "This study gives an overview of different varve integration methods with Bacon." sounds colloquial, I suggest elaborating, consider e.g. "…different methods to integrate information from varve chronology, radiometric measurements in Bayesian tool Bacon…"

We accept your suggestion and integrated your formulation in the text.

Line 79 and elswhere

Please correct the referenced name to "Bronk Ramsey, 2009" as this is a correct two-part surname for Christopher Bronk Ramsey

We apologize this error and corrected this mistake throughout the whole manuscript.

Line 149-153

Please include a brief information about the total length of the recovered cores, maybe refer to Fig. 2?

Thank you for your suggestion. This was also suggested by reviewer #1 and we have added this information as follows:

"The coring locations are distributed evenly along a 12 m-long transect with 4 to 4.4 m distance between coring locations. The recovered sediment cores have lengths of 2 m (HZM19-07, -08, -10) and 3 m (HZM19-11), which have been split in the field into 1 and 1.5 m-long sections, respectively. In total, HZM19-07 covers a sediment depth of 15.5 m (0-15.5 m), while the other sites provided different depth ranges: HZM19-08 (0.25 – 10 m), HZM19-10 (4 – 14 m) and HZM19-11 (1 – 19 m).

Line 181

Change "Spectroscopy" to "Spectrometry", the correct name for the AMS technique

We changed this as suggested in the revised manuscript.

Line 317

If possible, please enlarge Fig. 2 to full-page scale, would be easier to read

We enlarged Figure 2 to full page scale.

Line 422

Change "+ -" to "±"

We corrected this symbol throughout the manuscript.

Line 444

Inconsistent depth units: here 4.43m, in Fig A3B.: 4429 mm, would be clearer to unify

Line 490

As above, 6.29m in the text and 6312mm in Fig. A3D

We changed the depths in Figure A3 to a m-scale to keep it consistent with the other mentioned depths. For Figure A3D we implemented the correct breakpoint depth of 6.29 m and replaced it in the line plot.

Page 20, Fig. 5

Please add markers for hiatus due to technical gap and for LST, similarly to Fig. 6

We implemented both markers into Figure 6.

Page 22

Line 548 – delete double dot

Deleted as suggested.

Line 549 – please clarify, which transition do you mean here?

In this sentence, we refer to both transitions and give more details in the following sentences. We changed the sentence of line 549 as follows: "Moreover, both YD transitions have been predicted within the 95% confidence interval comparable to VT-99 (Table A6) and to the Meerfelder Maar record"

Page 37

Table A6 is difficult to read in its present format, in particular when reader wants to have a quick glance at some specific numbers. Check the line spacing and names of "events" in the first column. If possible, please add horizontal lines dividing the rows.

We agree that the structure needs improvements and reduced the line spacing.

References

Bonk, A., Müller, D., Ramisch, A., Kramkowski, M. A., Noryśkiewicz, A. M., Sekudewicz, I., Gąsiorowski, M., Luberda-Durnaś, K., Słowiński, M., Schwab, M., Tjallingii, R., Brauer, A., and Błaszkiewicz, M.: Varve microfacies and chronology from a new sediment record of Lake Gościąż (Poland), Quaternary Sci. Rev., 251, 106715, https://doi.org/10.1016/j.quascirev.2020.106715, 2021.

Brauer, A., Endres, C., Günter, C., Litt, T., Stebich, M., and Negendank, J. F. W.: High resolution sediment and vegetation responses to Younger Dryas climate change in varved lake sediments from Meerfelder Maar, Germany, Quaternary Sci. Rev., 18, 321–329, https://doi.org/10.1016/S0277-3791(98)00084-5, 1999.