

Geochronology Discuss., referee comment RC1
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Comment on gchron-2021-15

Anonymous Referee #1

Referee comment on "A Bayesian approach to integrating radiometric dating and varve measurements in intermittently indistinct sediment" by Stephanie Harmonie Arcusa et al., Geochronology Discuss., <https://doi.org/10.5194/gchron-2021-15-RC1>, 2021

A review of Arcusa et al. "New approaches to dating intermittently varved sediment, Columbine lake, Colorado, USA"

Manuscript number: gchron-2021-15

General comments

The manuscript by Arcusa et al. presents an important new approach to construct and improve chronologies based on the varved sediments. While it is applied to lake sediments, by principle it can be used also for other settings where dating is based on the annual increments of the material. This manuscript is a substantial development of the Bayesian approach, effectively combining strengths of the radiometric approaches and varve-based calendar age scales. Authors accurately identified sources of errors in the varve chronologies construction and aimed to minimize their influence by employing Bayesian methods. Generally, I agree with the discussion, as it is rather technical and brief in the interpretation of the environmental processes. In my opinion, manuscript is suitable for "Geochronology" journal and will gain wide interest, paving way for more accurate, reliable, and unified varve chronologies. However, there are some issues that need to be addressed prior to publication. This is especially length of the manuscript, which at times loses focus.

Specific comments:

Comment 1: I suggest that the Authors reconsider the title. Given that the manuscript

shows a promise for more general remarks it should be the focal point of the title. It looks like a great tool for sediment profiles with missing varves, but for entirely varved sequences it can be even better. There are strong points in the paper: R package, Bayesian varve-chronology model, integration with radiometric dates and so on.

Comment 2: This paper is introducing a new methodological concept, yet it lacks clearly resolved suggestions at the end (think Fig. 3 but even more general), and outlook. Generally speaking – which codebase and repository should be used in the future? One model integrates Gibbs sampler, the other does not and so on, is it going to be merged? By the end of the paper, there may be some expectations from the potential readers, that are not met at this point.

Comment 3: Integration of the geochemical data. It is interesting and useful to describe sediments, varve types and their formation (it is used to cluster the data, for example) and overall paleoenvironmental conditions. Yet, in my opinion, especially given the Introduction there is no clear indication for the geochemical data importance, it was unexpected addition. Because of that, manuscript seems to trail a little bit out of focus and is discussed with details that are not necessarily important. It is only at the end of the paper that the geochemical data is brought to the attention. There it is partially justified but it lacks in the context of the chronology development, even though it provides insights into the factors influencing the varve quality.

Comment 4: Authors suggest that missing lamina can be a result of erosion. Is there any evidence that over the history changing productivity and mixing could have changed formation and preservation of varves more than erosion? (5.1.1)

Comment 5: Do the Authors see possibility to expand the model with, for example, results from varve counting on geochemical and geophysical maps/profiles, which sometimes show better rhythm and separation of varves. If so, how varve quality codes would be associated with that kind of data?

Comment 6: Do the Authors see possibility to employ at least some of the proposed advantages to one-core sites? If so, then include it in the text. Multi-core research is often cost and time consuming, and not always possible.

Comment 7: I think that for the discussion of the rationale, there should be reference to VARDA database (Ramisch et al., 2020; <https://doi.org/10.5194/essd-12-2311-2020>) – an attempt to standardize varve chronologies with Bayesian modeling – it shows that it is an important issue worldwide.

Abstract:

L10-11: weather alternative archives are available or not varves still provide superior archives.

L11: chronology goes before paleoenvironment.

L15: "sediments", thin sections are just mean to preserve and investigate the material.

Introduction:

L35: maybe: due to time, density, and supply – however please consider that density itself is affected by time (compaction, post-depositional processes) so I'm not sure about putting it on the same line as time and source. In general, fluxes seem to be better but once there is a drastic change in sediment accumulation rate most of the constituents will likely follow. So relative representation is also useful.

L68-9: I'm not sure if parenthesis information adds to the introduction.

L73-4: "For example" at the beginning of the sentence and at the end.

L75: reveal intervals where missing varves can be inserted.

L80: I'm missing a link between these two paragraphs.

Last paragraph: Consider changing the order, first introduce rationale – there are few robust, long chronologies in the area and so on, therefore Columbine provides somewhat unique research material.

Study site:

L89/103: It' a matter of preference but maybe add m.a.s.l.

L91: formation and preservation...

L103: rephrase maybe so climate is not typified by the climate itself.

Methods:

L114: Probably UWITEC, without "H".

L117: "Error! Reference source not found".

L118: shallower depth meaning? Please put coring depth close to the respective core codes in L114. It's interesting to see what the change in depth was making that much difference in varve preservation.

L121: analyzed with non-destructive rather than for.

L128: minimum peak of what? Minimum reflectance peak/Rmean?

L134: what was the treatment?

L135: you provided details for previous methods, what was the equipment used here?

L148/155: reference to the papers is fine, but maybe consider adding package versions of rbacon, rplum and SERAC?

L150: line is redundant: statistical framework that uses statistical inference.

L151: why do you mention CRS particularly in this place?

L165: calibrated for/to what?

L175: what R version? There are important changes between the big versions like 3, 4 or 4.1.

L181: curious: why FactoMineR rather than base PCA?

L194: principle is general, so sections rather than thin sections.

L196: do you consider developing approach based on other file system, rather than proprietary shapefiles?

L196-7: what is necessary to record: depth and code/name of layer?

L215: if you introduce the paragraph properly, I see no need for 220-227 to be discussed after the code 6. It can and should be discussed immediately after 4. Especially that you introduce idea of simulation as code 6 was "similarly" emulated, but it is presented afterwards.

Paragraph starting at L229 needs to be more concise.

L245: there is already subject in the sentence, no need for Columbine Lake at the end.

L248: and expert judgment.

Paragraph at L255: rewrite to avoid redundancy from previous sections in Methods and try to be more concise. L260 no need for parenthesis.

3.8 and 3.9 can be as well one section. This subdivision seems unnecessary. Avoid redundancies.

L272: that kind of detail on algorithm etc. could go into the code comments or other kind of supplementary materials.

L277: if by adjusting – typo?

Results:

L303: I don't think that "redox" should be used as an adjective for any element (Mn). Its state is controlled/sensitive to redox changes.

L313: in the microfacies analysis...

Section 4.2 Please indicate that further in the text you are using "lithozones" to describe seasonal/event layers and structures within the varves. Also, first and second sentence can be shortened and merged into one.

L353: space missing in <5 (or remove space in previous notations).

L356: deeper. Try to be more concise.

L410: while I get that Bayesian model must produce confidence interval, the density region starting at 1679 CE seems to be strange by the definition if it is on the depth where unsupported Pb just vanished.

L415-420: maybe move some of the details to Methods and avoid repetition.

L450: space missing in <100 (or remove space in previous notations).

L4620: missing "I" in model.

Discussion:

L501: First part of the sentence and subjects are in mismatch. Chronologies versus profiles.

L507: structures of the...

L540: this is rather typical. Often these splits will occur on the unconformity between the layers of different density and properties.

Paragraphs from L560 to 590: although discussion of anoxia is important it is inserted between the two paragraphs on the source of the material and seasonal differences of supply. Furthermore, Authors repeat some of the information. Please, consider reworking this section.

Paragraph from L635: I advise caution in the Mn/Fe interpretation, even if these are mostly uncorrelated to lithogenic inputs. Seasonal relations are of importance.

Paragraph from L645: what about sediment focusing? Also, it seems that you started writing "C.E." from here on rather than previously used "CE".

Figures:

Figure 1: Color for vegetation is virtually the same as depth of 0 meters of the lake. Outline the lake and catchment, so legend/key and scale are separate entities. Elevation – see comment to L89. Inflow line in the key and on the map is narrow and hard to see. Caption: Columbine Lake.

Figure 4: Reconsider legend/key placement and structure. For example, varve types corresponding to the color bars in (a) are at the bottom of the box, and easy to omit.

Figure 5: Is it correct to describe the dendrogram as constrained or not, or rather it is a dendrogram showing the results of constrained clustering method? (b) increase contrast of the vector groups?

Figure 7: Figure shows an impressive improvement of the chronologies once they are integrated with the results of the radiometric dating methods. Yet, this part is discussed later in the paper, with figures in between.

Figure 8: Some of the figure caption is a repetition of the text, rather than figure description.

Figure 9: missing "l" in model.

Figure 10: Any comment on multimodal distribution?

Figure A2: Consider adding depth/length scales.

Figure A4: How was the Mn/Fe ratio normalized?

Figure A6: Matter of preference, but warmer color is associated rather with positive values and colder with negative, regarding correlation.

Please check figures and their captions in the text and Appendix for consistent use of (A), (B) and so on. For example, Fig A1, A5, A7 – capitalized, whereas others are not.

Code:

Please think about very short readme file describing the actual workflow and data structure to reproduce your research.

It seems that in the "varveR_Gibbs-v.1.0.0" there are missing extensions in the R scripts, which I assumed for the review to be typical ".R" files.

If the Authors consider releasing the same scripts with the Manuscript please check the code for instances like below, where full paths are provided.

`readLipd("D:/OneDrive for Business/...");` I cut the remaining path for clarity. Consider using `here::here()` or likewise so code is more reproducible. After this point **I did not** change all the paths to run the code.

Overall, code is commented, and consecutive blocks are explained. Examples are provided for functions and parameters are described. For the future releases of varveR some code cleanup is necessary, though.

