**Climate
of the Past
Discussions**

Interactive comment on "COnstructing Proxy-Record Age models (COPRA)" *by* S. F. M. Breitenbach et al.

Anonymous Referee #2

Comments on the manuscript "COnstructing Proxy-Record Age models (COPRA)" by S. F. M. Breitenbach, K. Rehfeld, B. Goswami, J. U. L. Baldini, H. E. Ridley, D. Kennett, K. Prufer, V. V. Aquino, Y. Asmerom, V. J. Polyak, H. Cheng, J. Kurths, N. Marwan.

The authors present a manuscript describing procedures to derive an age model with associated uncertainties for U-Th dated speleothems. A 'software' (i.e. a MatLab code) for these procedures is announced to be provided. An interesting feature of the presented procedures is the incorporation of additional chronological information, such as layer counting. This can greatly improve an age model. The authors recognise the importance of error margins for an age model and provide a code that does a Monte Carlo (MC) variation on linear, spline or cubic interpolation.

General comments:

The COPRA code itself is new, but the basic idea behind (i.e. design a code to derive an age model for speleothems based on U-series dates with MC-based confidence levels) is not. This manuscript follows other recent publications on the same topic (Scholz and Hoffmann, 2011, QG; Scholz et al., in press, QG; Dominguez et al., in press, QG; Hercman and Pawlak, in press, QG). The radiocarbon dating community has also developed various tools for distance-age modeling (e.g. Heegaard et al., 2005; Bronk Ramsey, 2008; Blaauw, 2010). Novel to some extend is the realisation how to incorporate layer counting as additional constraint (although see Dominguez-Villar et al., in press, QG). The title and abstract should be focused on the aspect of including layer counting rather than selling the code as the solution for 'ANY and ALL' proxy records. Generally more information about the interpolation itself is needed. What spline or cubic interpolation is used, how are parameters constrained? And on what basis is the interpolation method chosen? Any constraints, advice, guidance? Please show for your examples potential differences for the different possible interpolation options. Also, how do different choices for parameters for spline or cubic interpolation affect the results and how is a decision made? In its current version the manuscripts leaves too many questions open and many aspects of the age modeling seem to be somewhat random. This needs to be clarified, especially in the light of a claim for a reproducible approach. The proof of concept is not yet convincing. A synthetic data set should be used to address critical issues and show strengths and weaknesses of such an approach. However, the authors fail to do so. The example using synthetic data is not demanding at all. No 'outlier treatment' is really addressed, although this is one of the critical aspects. This can be seen by one of their stalagmite examples (TSAL-1) where deleted 'outliers' are not necessarily outliers and could / should not be deleted. Bottom line, a more demanding synthetic example is needed to demonstrate feasibility and limitations of the presented approach. I would generally criticise that - although the authors do mention that 'outliers' cannot simply be deleted without further evidence - the examples and the design of COPRA implies that deleting outliers is the appropriate standard procedure. Alternative handling / treatment of 'outlier' is not really considered

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in the manuscript. For example, all cases where data are deleted should be compared to an alternative by increasing error margins instead of deleting. Furthermore the authors do not follow their own statements and do not check / treat neighbouring data points of 'outliers', which would be important for the example TSAL-1. The authors vaguely leave many decisions to 'the experienced researcher' and fail to define what is meant by 'appropriate data handling / modification'. The functionality (and user-friendliness) of the code could not be tested / verified for this review because a final 'user-friendly' version was not available.

I cannot recommend publication in its current version. The authors need to address above issues and modify the manuscript / code accordingly before it can be considered for publication.

Detailed comments:

Abstract

line 5/6: The modeling and 'interactive handling of outliers and hiatuses' are separate issues. It is not the modeling that allows the 'interactive handling'. Interactive handling is data modification prior to modeling.

line 10: This statement could not be tested / verified. There was no final, easy to use version available for this review. Also, the easy to use version with gui will require a MatLab licence which should be mentioned.

Introduction

p2371 line 17: Generally a sampling position is given with distance to a reference point. Can be depth (for stalagmites distance from top) but also distance from bottom.

p2372 line 11: What is precisely meant by 'direct network analyses'? I could not find a description of this term in the cited reference.

p2372 line 15-23: This sounds as if the authors introduce the concept of an age model!

In line 23 they even claim that the presented method can construct an 'absolute' time scale for ANY and ALL proxy records. That sounds quite bold and I pretty much doubt that. The whole paragraph should be deleted.

p2372 line 25: Why do you change here from depth (or better distance) - age relationship (as correctly described in p2371 line 20) to age-depth relationship? I suggest to use the term distance-age model, relationship etc throughout the whole manuscript. Generally, looking at a stalagmite: every distance has an age, but not every age has a distance on a stalagmite. So the distance is the primary information and we measure (or assign/model) an age to it.

p2373 line 1: This statement is misleading. There are other approaches which also assign uncertainty to the age model.

p2373 line 6: The authors do not adequately describe potential of other already published age model approaches by stating '... helps to interpolate...'. As far as I can tell, COPRA is largely following previous publications such as StalAge but uses different interpolation(s) and has a different philosophy about data handling.

p2374 line 25f: Following above statement - this is a bit overstating a novelty. The code itself is new, but the idea behind (design a method to derive an age model with MC-based confidence levels) is not.

Methods

There are a lot of repetitions between 'introduction' and 'general remarks'. This can be substantially shortened.

p2375 line 3: Why are proxy data needed for an age model? The age model (i.e. assigning an age to distances of the stalagmite) does not depend on proxy data. Actually, the age model itself is some sort of a proxy since it provides timing of growth phases, changes of growth rate etc.

p2375 footnote: I agree with the footnote, but why do the authors use the term 'abso-

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lute' dating in some places (e.g. where the footnote is placed; p2372 line 12; p2375 line 20)? This could be part of the introduction making a case for not using this term.

p2376 line 25f: This is a vague and thus dangerous 'fundamental assumption': What is 'proper treatment'? The manuscript only describes deletion of data points as a treatment, although it also mentions changing error margins. However, the alternative of changing error margins is not described further anywhere and all descriptions of data treatment in the text lead to the conclusion that 'outliers' have to be deleted when using COPRA (e.g. p2378 line 20).

p2377 line 7f: Reproducibility strongly depends on the user. Using COPRA requires decisions made by 'the experienced researcher' (select interpolation, delete data points...). This is the case for every age model and thus they are also reproducible in case ALL decisions and treatments are documented.

p2377 line 14f: A few more references would be good in this paragraph. Using MC to derive uncertainties for non-linear systems is neither new nor novel. It is a good method to use and it is certainly ok to give an overview how it works. However, it could and should also be referenced.

p2380 line 14: This is a key statement which unfortunately does not seem to be further considered!

p2381 line 14: Please tell what you mean by '...'treated' by the user in an appropriate way...'. As far as I read this manuscript this will largely be interpreted as : 'delete data point'.

p2381 line 22: This is correct, so why do you not also highlight the neighbouring points as potentially problematic? You should also give guidance / examples for this scenario, e.g. using the example data set TSAL-1 or an appropriate synthetic dataset which includes all kinds of scenarios.

p 2382 line 20: For a statistic a minimum of ten data points are needed and even then:

only if it was expected that the values are scattering around a mean value a deviation could be detected. Growth rates can be hugely variable and a mean value is actually meaningless. A huge dataset would be needed to investigate whether there is a mean growth rate in the first place and then detect any significant deviation... Also, with few available data points this will be biased by the data density / distances between dated points. Thus, this approach seems not applicable to me.

p 2383 line 1: In what cases does COPRA identify a hiatus where there is none?

p 2383 line 17: You probably mean a more precise age model.

Application

p 2385 line 20f: The synthetic dataset is disappointing. Such a dataset should be used to highlight and demonstrate strengths (and potential weaknesses) of the model. All you show in Fig. 6 is a non-demanding dataset without any problematic feature. This is far from convincing. Although you describe such features (line 7), they are not presented. You need to show: dataset with 'outlier' (and no evidence for the data point to be suspicious) and how does COPRA work a) deleting b) keeping the 'outlier'. Same for a hiatus...

p 2386 line 26: How do you know that one age is suspicious due to contamination in the laboratory and how can you exclude this for the other data points (i.e. how realistic are the errors for the other data points)? Why would you report an age anyway if there was contamination in the lab?

p 2387 line 6: You cannot assign a hiatus by fabrics. Fabrics indicate a discontinuity, but this could also be without a growth stop (e.g. a single short event). A hiatus can only be assigned by independent dating, the fabrics then help to place the hiatus at a certain distance.

p 2388 line 21f: As mentioned before, this paragraph needs more work. The synthetic example should cover and demonstrate handling of problematic features. You show

just a nice non-problematic example.

p 2388 line 25: Why are these 'in fact outliers'? The decision that these are outliers is based on what grounds? Why not also look at neighbouring points? IN FACT: a close look at Fig. 4 and Fig. 7 is a bit confusing. Maybe it is the quality of the figures, but error margins do not seem to be the same on the two graphs. In Fig. 4 the age around 100 mm seems to just overlap with ages at greater depth with exception of 140 mm. So why is the point at 100 mm the outlier? Other evidence available? Interestingly in Fig. 7 the overlap disappeared. Anyway, it is mentioned that the age at base has a lab contamination issue, so how confident are you about error margins of the other dates? Maybe errors are larger. Also: on what base did you decide that the second point from top is the outlier and not the third? Both options are possible and it is not clear to me why 'in fact' this point was chosen. This highlights that other users would probably derive a different age model from the same data set (at least very different uncertainties around the distances where you deleted points), questioning the reproducibility of this approach.

Discussion

p 2390 line 16/17: What do you mean by 'information-content-based approach'? Is this meant to be something unique? Actually, all research should be information content based... And only accurate data should be used anyway, so this is no special limitation.

p 2391 line 18f: An increase in accuracy still needs to be shown, e.g. by an appropriate synthetic data set which returns an inaccurate age model without extra information such as layer counting.

p 2392 line 3f: This is an interesting approach. However, more discussion would be good here about the concept and implication to assign an age uncertainty into proxy uncertainty. To some extent it represents a running mean for points within an age range. However, in most cases a structure in proxy data is real if outside proxy data uncertainties, just the relative timing / age is uncertain. Thus, it might also be interest-

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ing to show different realisations of the proxy data on possible time scales.

Conclusions

p 2393 line 10: Actually, I think I missed the definition for 'outlier definition' in the manuscript. As the example TSAL-1 shows, the outlier definition for this sample is at least questionable. This underpins your statement in line 6 and COPRA does not overcome the issue in its current version.

Interactive comment on Clim. Past Discuss., 8, 2369, 2012.

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