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Climate of the Past Discussions

Interactive comment on "A modelling approach to assessing the timescale uncertainties in proxy series with chronological errors" *by* D. V. Divine et al.

M. Blaauw (Referee)

maarten.blaauw@qub.ac.uk

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General comments

This manuscript proposes a Bayesian method to produce age-depth models for fossil proxy archives that have absolute dates without chronological uncertainties. Accumulation/sedimentation between the absolutely dated points is simulated using gamma distributions (if I understand this correctly). This method is a variation on existing (although largely uncited) methods, and as such I wonder what the proposed approach adds. I also have doubts about some aspects of the method. The text is not always unambiguous and should be thoroughly reviewed by a native English speaker. Pending

these major revisions, I could consider accepting this manuscript for publication.

Comparable age-depth model approaches exist even though they are hardly mentioned in the text. OxCal's P_Sequence (Bronk Ramsey 2008) simulated sediment accumulation by Poisson models. BChron (Haslett and Parnell 2008) does almost the same thing as your ms, in using gamma distributions. Bacon (an "update" of Bpeat; Blaauw and Christen 2011) additionally includes priors on accumulation rate as well as a dependency of accumulation rate between neighbouring sections. Perhaps your method approximately equals Bchron, or Bacon with a memory of 0? Then there are also other, non-Bayesian published methods such as StalAge (Scholz and Hoffmann 2011) and clam (Blaauw 2010). Provide a detailed discussion of, and comparison with, relevant alternative approaches. How does your method improve on these published ones? Can it deal with calibrated (multi-modal, asymmetric) C14 dates?

This method is applied to cores dated by tie-points that have no chronological uncertainties, which to my experience is rather uncommon. Please include a case study of cores where the dates have chronological uncertainties.

As you note, the ever so popular model of linear interpolation between dated depths has a major problem of ignoring any potential variations in accumulation rate between dated points. Accordingly, the error estimates in Fig.6 seem overly optimistic. Bacon, Bchron and P_sequence try to do better in this respect, modelling a varying accumulation rate. Is it realistic to expect no "memory" going from one dated section to the next one?

Regarding the case-studies, how reliably linked are the tie-points (tephras, dust events, turbidites) to historical events? Could mis-identifications have led to wrong alignments (Blaauw in press)? This is not trivial since wrongly identified tie-points could produce high-precision but entirely flawed chronologies.

I am not a statistician and can thus not critically evaluate the technical details of some sections (e.g. 2.2). However I have some doubts about the adopted MCMC procedure.

1) (By how much) do you thin the iterations in order to obtain a set of (semi-)independent iterations?

2) To my knowledge, the approach of first sampling K ages and then N * K age-models is highly unusual, and might lead to under-estimates of the true distribution of the errors. Has this been done before and proven to lead to proper error estimates? Provide citations, or alternatively look at how other MCMC-based age-depth modelling approaches deal with this.

Somehow the errors as modelled in Figs 2,4 and 6 appear strange to me. Why do they look like a "balloon dog" or a "string of sausages", with very strongly inflating errors just outside of the dates? Should common sense not indicate that the errors should instead inflate more with a sigmoidal shape (think Gaussian distributions connected at their tails), i.e. we know more or less the date of sections close to dated depths?

Section 4 needs a case study. It also would be good to explain what you're doing here in words that are easier to understand.

Specific comments

p33,9-10 include other common dating techniques such as OSL, tephra, d18O stratigraphy...

p34,12 should this be |d_{i+1} or |d_i ?

p34,21 cite clam?

p35,3-7 not a new approach, cite published age-depth models that do the same

p35 even if a sequence of depths and points is monotonous, a curve drawn through it (e.g. smooth spline) could still show reversals. It would be better to explicitly avoid age reversals in the age-depth curves (e.g. OxCal's P-Sequence, Bacon, Bchron, Bpeat).

p35,18 this approach might not work if a date is outlying (would be very hard to model the correct age simply from its 1sd error and a Gaussian distribution)

p36,1, what does this equation mean in words?

p36 mention a very useful aspect of the gamma distribution for accumulation processes: x is always >0!

p37,6-8 unclear, what does this mean? Explain much better

p40,18 were uncertainties of layer counting estimated?

p43 did you count the varves or are you referring to published work?

p44 impact of choice of parameters, see Bacon or parameter k in OxCal's P_sequence

p45,6 which OxCal model, method and settings?

p45,16 see greyscale proxy graphs in for example Blaauw in press (Fig. 5b)

p49,14 Queen's Univ. Belfast

Fig1, translations of parameters a&b into mean and shape might make them easier to interpret in terms of their impact on modelled accumulation rate (see Blaauw and Christen 2011)

Technical corrections

The text has myriad spelling problems (too many to mention here), especially with absent or wrong articles ("a", "the"). Have the text thoroughly checked, also because these mistakes sometimes introduce ambiguity

p33,9 explain acronym AMS at first use

p39,11 tie-points that are non-fixed in time

p39,22 two ice cores, one lake core

p43,8 , which potentially

caption Fig.1 parameters

References

Blaauw, M., 2010. Methods and code for 'classical' age-modelling of radiocarbon sequences. Quaternary Geochronology 5: 512-518

Blaauw, M., Christen, J.A. 2011. Flexible paleoclimate age-depth models using an autoregressive gamma process. Bayesian Analysis 6: 457-474

Blaauw, M., in press. Out of tune: the dangers of aligning proxy archives. Quaternary Science Reviews

Bronk Ramsey, C. 2008. Deposition models for chronological records. Quaternary Science Reviews 27: 42-60

Haslett, J., Parnell, A. 2008. A simple monotone process with application to radiocarbon-dated depth chronologies. Applied Statistics 57: 399-418

Scholz, D., Hoffmann, D.L. 2011. StalAge - An algorithm designed for construction of speleothem age models. Quaternary Geochronology 6, 369-382

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