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Climate of the Past Discussions

Interactive comment on "Similarity estimators for irregular and age uncertain time series" *by* K. Rehfeld and J. Kurths

Anonymous Referee #1

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General comments This paper deals with the relationship between paleoclimatic data sets (time series) on one hand, expressed through similarity indices, and consequences of sampling irregularity and age uncertainty on the other. These two issues are relevant for all climate archives to different degrees. Comparing two time series from different locations implies comparing values (for proxies) not obtained at the same moment in time, and the number of observations (length of the series) will also be different in general. These two obstacles render application of many comparison methods impossible. The paper tries to deal with this situation properly.

To compare two such series, five different similarity estimators are used, which are extensions or alterations of methods already in different contexts. The classical Pearson correlation coefficient in two different versions, weighted based on Gaussian kernels

or on interpolation, the Mutual Information in the same two versions, and an event synchronization index based on thresholded values ("extremes"). This list might easily be extended, and the authors unite the different similarity indicators to a scalar quantity termed "link strength" reflecting the fraction of significant indicators (based on the null hypothesis that there is no similarity between the series). Provided a significance test (based on MC simulations using reference processes leading to two mutually independent series) is available for each and every indicator, the link strength can be extended to an arbitrary number of similarity measures.

The paper continues with a description of each of the similar measures. An effort has to be made to adjust the classical definitions to situations where both sampling irregularity and uncertainties in the independent coordinate (time) are present. These alternative versions are not free of assumptions or parameters; in particular, the Gaussian kernel comes with a bandwidth which has to be chosen. The interpolated version is not described to any detail in the paper, but in any case some decisions how to interpolate have to be made, and these clearly affect the resulting similarity. The parameter choices are reported but not discussed in the paper.

The event synchronization is different since it is the only measure which does not require kernel smoothing nor interpolation; the attribution of individual proxy values to "events" is nonetheless subjective, i.e. comes with a parameter which have to be fixed beforehand.

To benchmark the different similarity measures, synthetic time series are generated mimicking stalagmite growth histories. Here, the paper is not fully explicit as to their construction and the uncertainty in the growth rates; reference is made to previous publications, but the reasons why the climate at one location is impacting the growth rate at the other remain unclear. At this point, a hint towards assumed teleconnections and the Indian-East Asian summer monsoon system which is relevant for the observations from the two caves could be given at this point.

Results show that for age uncertainties and irregularities typical for experimental situations, the similarity indicators are substantially affected. In particular age uncertainty is difficult to mitigate. Already at moderate levels of imprecision, the measures fail to identify correctly the lag which maximizes the similarity of the series, and the coupling strength cannot be reconstructed. The authors point out clearly that every effort has to be made to reduce age uncertainty, but this is a burden for the data sampling, not for the analyst.

Finally, the paper also includes measured data from two caves. It is quite disappointing that none of the measures is performing satisfactorily; the confidence intervals obtained through Monte Carlo sampling are rather wide when using the age modeling of COPRA, and thus results are rather inconclusive as to the connection between the two time series. For this example, the method could not prove its potential; the reviewer wonders whether there are other time series pairs (showing stronger lag zero correlation) where conclusions would be different?

The potential of the method is obvious. Accepting the fact that there is no single similarity indicator suitable for all processes and time series, the consideration and ultimately combination of several or many of them is a logical next step. Which ones to choose is a matter of taste and knowledge, the authors point out other possibilities (CRPs, RNs, distance measures) towards the end of the paper. The reviewer strongly advocates yet another, recently developed method, dedicated to the identification of causal connections in the presence of noise, which is called Convergent Cross Mapping (Sugihara et al., 2012).

Reference: Sugihara, G., May, R., Ye, H., Hsieh, C.-h., Deyle, E., Fogarty, M., Munch, S., 2012. Detecting Causality in Complex Ecosystems. Science 338, 496-500.

Specific comments

The paper is occasionally written in a pedagogical manner, resembling a lecture or textbook chapter. This is at times unnecessary for a research paper in Climate of the

Past. Every researcher and reader of this journal is aware of the concept of a time series and does not need a definition for it, or, for that matter, one for the concept of an age model (p. 5305). At several other places, there is potential for shortening; overall, the paper is quite lengthy. A too strong resemblance of the content of the thesis of the first author should be avoided; a thesis has different demands and more space than a research article.

On the other hand, some aspects crucial for understanding the approach and its details are left out or referred to citing other publications only. The details of interpolating one of the series to produce "observations" at the same times as the other series. Surely, also here there are plenty of possibilities which will affect the performance of iXCF and iMI. Another example is the reasoning for using the gamma distribution for the accumulation times; two sentences of explanation would be superior to the phrase "Please refer to Rehfeld et al. (2011)...".

Technical corrections

There are a number of errors in the equations (notation), typos and omissions, which are commented upon in the attached pdf document. Please consider all of these carefully. In addition, reducing the number of definitions and thus the apparent formality of the paper increases comprehensibilty and accessibility.

Conclusions

The paper should be acceptable for publication after the modifications indicated. The workload coming with the revision qualifies it as "minor". The reviewer would like to see a comment whether there are other, more promising data sets demonstrating the advantages of the method; if not, how to demonstrate the advantages of the method? This is critically important. Among the candidates for similarity, please add the convergent cross mapping [Dear authors, no, your conclusion is incorrect: the reviewer is not among the authors of the corresponding paper.]

When do you expect the first edition of the NESToolbox written in R?

Please also note the supplement to this comment:
http://www.clim-past-discuss.net/9/C2537/2013/cpd-9-C2537-2013-supplement.pdf

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