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Climate of the Past Discussions

Interactive comment on "Inferring climate variability from nonlinear proxies: application to paleo-ENSO studies" *by* J. Emile-Geay and M. P. Tingley

Anonymous Referee #1

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This quite educational manuscript explores the consequences of assuming a purely linear relationship between climate forcing and a proxy record in the cases when this relationships presents some type of non-linearity. The manuscript also suggests two ways of coping with non-linear links between climate and proxies in order to reduce those reconstructions errors. The two proposed methods are a transformation of the proxy record to bring its probability distribution closer to gaussian, and a more complex Bayesian approach that requires a more realistic mechanistic modelling of the proxy. Without attempting to be exhaustive in the possible solutions to the problem of a non-linear link between proxy and climate, the authors suggest that a reasonable trade-off between complexity and utility can be achieved by transforming the proxy to

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a gaussian variable. The manuscript illustrates these questions first with pseudo-proxy experiments and then later with two real proxies of ENSO that happen to present different probability distributions and that therefore their link to ENSO has to be non-linear, assuming that both map the same climate forcing.

I enjoyed reading the manuscript, both for its educational content and for the pragmatic approach that the authors have taken to, en the end, offer a useful advice to the practitioners of climate reconstructions. The manuscript is sometimes dense but it is well written and can be readily followed, as the authors have taken care of not getting very much entangled in theoretical formalism that may had put off some readers.

I am happy to recommend its publication in Climate of the Past, although I have some minor suggestions that could be addressed in a slightly revised version.

1) I was a bit irritated by the equivalence that the authors assume between non-linear link between climate and proxy and a non-gaussian distribution of the proxy record. These two concepts are only equivalent when the climate record is itself normally distributed. The authors more or less explicitly acknowledge this caveat in the text, but this caveat is some what hidden and appears a bit too late to my taste. Later, this conditionality - that the climate record has to be normally distributed- is just assumed. Whereas this might be true in most situation, I guess that some readers may get initially confused. Also, it might be not true in for some climate records. In those cases, the proxy record should be transformed to the same distribution as the climate record, and not to a gaussian distribution. I think the whole argument would gain clarity if this were explicit stated some where in the manuscript, better sooner than later.

2) The assumed non-linear relationship describes only some type of non-linearity. The title is thus a bit too general, as some researchers from the tree-ring community and maybe from other communities, could assume that the meant non-linearity would be of the non-invertible type , e.g. a value of tree-ring-width corresponding to two possible values of temperature striding the temperature of optimal growth. The manuscript

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clearly does not deal with this type of non-linearity.

3) The authors are candid when discussing the apparent superiority of the Bayesian approach, as it the study assumes the exact knowledge of the data generating process and even of the values of the model parameters. I was wondering how the results would look like if the value of the non-linear exponent β in the data generating process were slightly different from the assume value, or in other words, how the uncertainty in β would influence the skill of the Bayesian approach. I guess that in real situations, the value of β will have to be estimated, as the authors also recognize and this may require computing intensive sampling methods, but maybe the authors could conduct more simple calculations in which $\beta_{generatingmodel}$ and β_{bayes} are slightly different.

Minor points

4) The authors seemed to have followed the American spelling, at least I could spot a few ' modelings'

5) The following are examples in which a non-gaussian distribution is equated to non-linear proxy without any caveats:

2006; Tolwinski-Ward et al., 2011), karst effects in speleothem δ O records (Baker et al., 2012; Jex et al., 2013), and hydrodynamic effects in flood proxies. Nonlinearities are especially pronounced in terrestrial proxy records from the tropics, where temperature experiences its lowest dynamic range and precipitation its highest dynamic range, resulting in distributions that are non-normal, with strong positive skew. These records

Nonlinearities often manifest themselves as non-normality in the proxy distribution, despite the target climate quantity being well approximated by a normal distribution.

Interactive comment on Clim. Past Discuss., 11, 2763, 2015.