

## ***Interactive comment on “Was the Little Ice Age more or less El Niño-like than the Mediaeval Climate Anomaly? Evidence from hydrological and temperature proxy data” by L. M. K. Henke et al.***

### **Anonymous Referee #2**

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This is one of the most difficult reviews I've had to do. Not because the decision is ambiguous (it isn't), but because the subject of the paper is potentially important, and the authors seem well-intentioned. Unfortunately, the research is so poorly designed that I don't think it has in place in this (or any) journal, unless it is completely overhauled.

Here are some of the most egregious ones:

# ENSO definition ENSO is an interannual phenomenon. Looking at 30-year averages and calling that ENSO is more than a stretch. That choice was not explained partic-

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ularly well in the paper, though it has major consequences for the research, blurring interannual and decadal signals, and drastically reducing the number of degrees of freedom.

# climate target The whole point of pseudoproxy experiments is to have a known target to compare to. The authors choose instead an assimilated product (20CRv2), which is then "replicated in the time dimension to get a length of 1000 years" (B4, L12). This is madness. Why not use a CMIP5/PMIP3 simulation? Since the authors are not using their method to generate an actual reconstruction that they seem to believe in, they might as well stay in pseudoproxy land, where they would have perfect control over the experimental design.

Instead, they have to make up some data from the 20C reanalysis through unspecified means, which is downright scary. At the very least, the generating mechanism for the data needs to be transparent.

# pseudoproxy design

The field has evolved a bit in recent years, now enabling the generation of more realistic pseudoproxies using proxy system models (Tolwinski-Ward et al, 2011; Dee et al 2015). Using an explicit process model of tree-ring growth, Evans and al (2015) found quite different results from the usual "climate + white noise" pseudoproxy design.

Evans, M. N., J. E. Smerdon, A. Kaplan, S. E. Tolwinski-Ward, and J. F. Gonzalez-Rouco (2014), Climate field reconstruction uncertainty arising from multivariate and nonlinear properties of predictors, *Geophysical Research Letters*, 41(24), 9127–9134, doi:10.1002/2014GL062063.

Dee, S., J. Emile-Geay, M. N. Evans, A. Allam, E. J. Steig, and D. M. Thompson (2015), PRYSM: An open-source framework for PRoxY System Modeling, with applications to oxygen-isotope systems, *J. Adv. Model. Earth Syst.*, 7, 1220–1247, doi:10.1002/2015MS000447.

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Tolwinski-Ward, S. E., M. N. Evans, M. K. Hughes, and K. J. Anchukaitis (2011), An efficient forward model of the climate controls on interannual variation in tree-ring width, *Climate Dynamics*, 36(11-12), 2419–2439, doi:10.1007/s00382-010-0945-5.

They authors pay lip service to it in section 5.1 but don't actually use it. Given that their paper is entirely centered on pseudoproxies and that all these PSMs are publicly available, they have no excuse but to keep up with the times.

# unjustified proxy selection

Nowhere in the paper could I find a rational justification for the choice of proxies. It leaves out the best ENSO proxy developed for the past millennium (Cobb et al, 2003), and incorporates many dubious ones from regions that have only marginal teleconnections to ENSO.

# fanciful statistics

the statistical methodology used for reconstruction is an extreme version of principal component regression, truncated at 1 pattern. This in itself is not the worst thing, but PCR is known to yield extremely biased reconstructions in the presence of noise. Total least squares (orthogonal regression) can mitigate that a bit, but PCR isn't outlandish as a first pass. However, the effect of this truncation on ENSO reconstruction should be assessed. For instance, it is known that ENSO tends to be split among different modes (most commonly, EOFs 1 and 2 of monthly-mean SST), so only selecting one can leave out an important part of the signal.

But the worst part of the procedure is the generation the pseudoproxies and then double-dipping between the calibration and verification periods. The authors claim that it "somewhat compromises the independence of the validation"; actually, it completely compromises it. There is no validation unless it is entirely independent of calibration.

The bottom line is that by focusing on 30-year averages, they leave themselves so few degrees of freedom that there is no room for validation any more. This would be

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mitigated by using long GCM integrations, (1000 years / 30 ~ 33 d.o.f., not very high, but better than 1 or 2). Even better would be to look at annual signals, since so many of the proxies are annually resolved and since ENSO is in the 2-7y band.

Another major problem is that the CE statistic appears to be benchmarked against white noise predictors, whereas with 30 year averages one needs to account for very high levels of autocorrelation, which alone are enough to doom the results.

# spatial pattern the question of whether the MCA was El Niño or La Niña-like seems to have been largely motivated by the work of Mann et al (2009). Wang et al (2015) showed earlier last year that it was an artifact of the dataset and method they use, and that changing either would change the result. A paper focusing on this question should acknowledge this research.

Wang, J., J. Emile-Geay, D. Guillot, N. P. McKay, and B. Rajaratnam (2015), Fragility of reconstructed temperature patterns over the common era: Implications for model evaluation., *Geophysical Research Letters*, doi:10.1002/2015GL065265.

# unclear methods a lot of the methodology is unusual enough that it needs to be very thoroughly presented here. I deplore the lack of equations to explain how certain things were done. Public code would be another way to enable an actual peer-review of the methodology.

# Moy The record by Moy et al keeps being used as an "ENSO" proxy, though some of its authors have since retracted their interpretation of it. <http://www.sciencedirect.com/science/article/pii/S0277379108001352> The community has got to stop clinging to an outdated interpretation.

# quirky problematization

Science progresses by "standing on the shoulders of giants". While none of the published ENSO reconstructions are perfect (they are most likely all wrong), they should serve as a starting point of the analysis. While the paper does cite recent ENSO re-

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construction at one point or other, it seems to happen as an afterthought; instead, the divergence between published estimates should really be the point of departure of the analysis.

There are many more errors, but I think I will stop here.

In summary, short of taking stock of the existing reconstructions, modern reconstruction methods, PMIP3 simulations, and new tools to generate more realistic pseudo-proxies, I do not see any point in this paper. It needs to be redone entirely to be of any interest to the community.

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Interactive comment on Clim. Past Discuss., 11, 5549, 2015.