

Interactive comment on “Inferred changes in El Niño-Southern Oscillation variance over the past six centuries” by S. McGregor et al.

Anonymous Referee #2

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Review of cpd-9-2929-2013 Inferred changes in El Niño-Southern Oscillation variance over the past six centuries S. McGregor, A. Timmermann, M. H. England, O. Elison Timm, and A. T. Wittenberg

Reconstructing the long term variability of ENSO is important for understanding present-day ENSO dynamics, and combining proxy climate records is an excellent way to extract and enhance the common long term ENSO signal. Extracting common ENSO signals is challenging however, because the proxies often record different ENSO-related parameters, can be from regions teleconnected to the ENSO centre-of-action and therefore may only record a partial ENSO signal, and/or may be discontinuous or include dating errors. This manuscript present a new and simple method for combining proxy climate records to extract that common ENSO variance signal. Ap-

C1552

plying this technique to proxy records that span some or all of the past few centuries suggests that the interval from 1979-2009 displays largest ENSO variance.

I am supportive of this manuscript being published in Climate of the Past and feel that there are two main points that need to be addressed before this can be achieved:

1) The main ENSO reconstruction using the MRV technique should be based on the single site proxy data. 2) Wording in the figure captions needs to be improved, consistent terminology is needed between the main text and the captions, and some parts of the text must be clarified.

I have expanded on these points below in an effort to assist the authors in revising the manuscript. _____

1) The main ENSO reconstruction using the MRV technique should be carried out on the single site proxy data.

The authors argue that the lack of independence of the multi-proxy reconstructions may enhance the noise component distort the common ENSO signal. This is a valid point but my concern is actually the opposite. That by using the same proxy record in multi-proxy reconstructions, and then combining the multi-proxy reconstructions, (and including some of the original proxy records again), the ENSO signal may be artificially enhanced. The multi-proxy reconstructions have already in some way filtered the ENSO signal from the noise and this already-filtered signal is combined (by the new MRV method) with other already-filtered signals (from other multi-proxy reconstructions) to get a common signal that has a potentially stronger ENSO.

After discussing the independence of the various multi-proxy synthesis products, the authors then go on to make an MRV reconstruction based on independent data (i.e. using individual proxy records only (no synthesis products)). Why not simply present that single site-based ENSO reconstruction and leave it at that. I feel that this would be a far better estimate of our state of knowledge of ENSO for the past 600 years,

C1553

even if it does contain ENSO variance data that appears anomalous compared to the common reconstruction (e.g. some of the pink dots in Figure 9a and c). I strongly recommend the authors present their single site reconstruction as their main ENSO synthesis product. Looking at Figure 9 I don't think it will change their overall conclusion but it will give us confidence because it is based on truly independent data.

Also on Figure 9, which are the records that appear anomalous (i.e. above the red line in Figure 9)? I feel the authors need add some discussion of these specific records and why they might be different.

Why the East African lake varves not included in the single site-based reconstruction?

2) Wording in the figure captions needs to be improved, consistent terminology is needed between the main text and the captions, and some parts of the text clarified. This may seem a trivial point but at present it is very difficult to follow what was presented in the figures and improving this will allow better understanding of the research and others to adapt the technique for different proxy climate syntheses. Wording between the figure captions and text is often inconsistent making parts of the manuscript very difficult to understand, at least for me. I have listed the parts I found most confusing below, and made suggestions as to how to improve the wording. Note: also included in the points below are additional comments and recommendations.

Abstract:

"These paleo-proxy reconstructions have typically attempted to reconstruct the full temporal variability of ENSO, rather than focusing simply on its variance." What does "full temporal variability of ENSO" mean in this context? Aren't the records proxies for a given climate parameter where that parameter varies on annual, interannual, decadal etc. scales, and isn't ENSO by default the interannual band, so what do you mean by the "full temporal variability of ENSO"? This for me doesn't mesh with "focusing simply on its[ENSOs] variance" – ENSO variance being the interannual band can itself be modulated on multidecadal scales. May you please define these terms.

C1554

"Here a new approach is developed that synthesizes the information on common low frequency variance changes from various proxy datasets to obtain estimates of ENSO variance" Synthesising variance to estimate variance is confusing. Do you mean extract the ENSO variance from individual records and then combine those to extract the common ENSO variance? May you please clarify.

"we find that the common ENSO variance over the period 1600–1900 was considerably lower than during 1979–2009" This sounds like a 300-year period is being compared to a 30-year period, which is a bit of an unfair test for the 1979-2009 period. Rather, do you mean that ENSO variance for 1979-2009 is higher than the common ENSO variance for any 30-year period during the interval 1600-1900? Please clarify.

Introduction:

"i.e., that a good temporal correspondence between a given climate variable and ENSO translates also into a high correlation between multi-decadal variance changes in this variable and in ENSO." Is it possible to give a specific example?

Methods:

". . . whether a good temporal correspondence between a given regional climate variable and ENSO can be used to imply that the variable will also provide a good representation of ENSO variance." May you give a specific example of where this is and isn't the case – this will help in understanding the subtle difference between a variable's correspondence with ENSO and its ability to capture ENSO variance.

Why was surface air temperature selected and not sea surface temperature (SST)? These parameters are strongly correlated in the tropics, granted, but the coral proxies are at least partially SST. Perhaps you could add a couple of sentences explaining?

"Two maps" and "two spatial maps" are confusing as you could be comparing contours and colours, or 2a, 2b, 2c, and/or 2d maps.

"Carrying out the same analysis for CM2.1 and CCSM4 precipitation data reveals some

C1555

interesting differences between the running variance (precipitation running variance – ENSO running variance) correlation patterns and the raw (precipitation – ENSO) correlation patterns in the tropical Pacific (Fig. 2b and d).” Which figure part is which? The use of “-“ (e.g. precipitation running variance – ENSO running variance) makes it seem like you are subtracting these parameters but that’s not actually what’s been done. Also, the syntax is ambiguous – you could be comparing CM2.1 vs CCSM4, or comparing the individual parts of the figure, whereas you are actually comparing the correlation patterns. This is also an example of what I described for the figure caption where the terminology is different from the caption making it hard to understand. Please reword for clarity.

“These differences between the correlation maps are reflected by the spatial correlations (r) of 0.67 ($r^2 = 0.45$) and 0.55 ($r^2 = 0.31$) respectively.” Again ambiguous. Are the spatial correlations for the information on the maps or between the maps? And which r (r^2) values corresponds to what?

“...variance of ENSO binned according to the correlation between precipitation and ENSO.” This phrase made no sense to me until I looked at the figure. Is it possible to clarify? “For instance, in CM2.1 if a precipitation signal is selected that has an r^2 value of between 0.6 and 0.7 when compared with the time series of ENSO SSTAs, there is a 10% chance that the running variance of that precipitation time series will have no significant correlation ($r < 0.31$ or $r^2 < 0.1$) with the running variance of ENSO (Fig. 3a). This indicates that ENSO may influence the sign and timing of the rainfall change at this location, however unrelated processes influence the magnitude of that change.” This is a very interesting point however it took multiple reads and flipping between the text and figure before I got what was going on. I think the issue is the phrasing of “10% chance” – could the terminology simply be changed to have the same values as the y-axis?

“running variance of the median (common) precipitation data” Again different from the figure – could you put in brackets “50% quantile” to make it easier to identify what you

C1556

are referring too?

“For instance, if we pick two geographic locations for which the median (common) precipitation signal has an r^2 of between 0.6 and 0.7 with ENSO, there is only a 1% chance that that the running variance of that common precipitation time series will have no significant correlation ($r < 0.31$ or $r^2 < 0.1$) with the running variance of ENSO. This is 10 times less likely than the case with precipitation data only sourced from one location. This result is consistent with CCSM4 data which suggests a common precipitation signal, from two geographic locations that have r^2 of > 0.7 when compared to ENSO SSTA, will make it 3.5 times less likely that the running variance of that signal will have no significant correlation ($r < 0.3$ or $r^2 < 0.1$) with the running variance of ENSO (Fig. 3b).” I’m afraid I was confused here too: 1% chance, 10 times less likely, r/r^2 values, and then r^2 on the figure 3 y-axis – I can’t keep track of what’s being compared with what. Perhaps start by stating the figure 3 y-axis values for the things you are comparing and then move on to state the % chances and likelihoods?

Page 2935 final paragraph. This is a nice summary of the model results. Why not test other parameters ENSO-relevant commonly reconstructed by climate proxies?

Figure 2 caption:

This figure caption took several reads and a lot of back and forth to the text for me to understand what I was seeing, when once I got it I realised the concept was really quite straightforward. I think this caption (and all captions, actually) could be improved with: a) A title sentence stating what the figure is about b) Some clearer definitions that are consistent between the captions and the text. For example, define the HPF annual mean (July-June) anomalies as something along the lines of “simulated raw” Ts/precip. Then the contours become the correlation between “simulated raw” data and annual mean N34 SSTA. Colours become the correlation of 30 yr running variance of the simulated raw data with the 30 yr running variance of annual mean N34 SSTA. Note for the contours it is written as “annual mean N34 SSTA”, whereas for colours

C1557

it is “HPF annual mean N34 SSTA”. This chopping and changing occurs for several parameters and add to the difficulty in understanding the caption (and related text). c) Then add a sentence somewhere explaining what the figure means e.g. That for Ts raw data and 30 yr running variance show similar correlation patterns with annual mean N34 SSTA, whereas these correlation patterns for rainfall often differ.

Figure 2 part labels – there are two “c)”s.

Figure 3 caption:

“The inset histogram displays the distribution of squared correlation coefficients calculated between precipitation running variance and the running variance of ENSO from the identified x-axis (grey shading) bin.” I read this numerous times and I just couldn’t figure out what had been plotted. Also, what are the black and blue lines in the normalised counts plots? I’m sorry I can’t make any suggestions as to how to reword but I really didn’t get this.

I struggled to distinguish the “+” symbols from the “x” symbols in the figure. Perhaps try circles and triangles?

Section 3.2.1:

Opening paragraph. This could be made clearer by adding a plain-english sentence describing MRV and RVM (perhaps this needs to come earlier in the paper). E.g MRV = calculate the running variance for the interannual band for each individual proxy and then calculate the median of all of those. RVM = combine the individual proxies first and then extract the interannual band and calculate the running variance.

I note there’s no callout to Figure 5b and d.

Section 3.2.2:

“What varies between these four sets, however, is the ratio of the time series that is subject to the introduced temporal shift, changing from 1/5, 1/4, 1/3, and 1/2.” Do you

C1558

mean then that one fifth (or one quarter etc.) of the records are shifted randomly by between 1-5 years? Could you add a follow up sentence to clarify what you mean?

Figure 7 caption:

Include a reference to table 4. Also, there’s another new term in the caption “observed ensemble median running variance” – please relate this to table 1 and the wording in the text.

Figure 9 caption:

What is the difference between the “ensemble median running variance” and the “observed ensemble median running variance”? I presume these are the same thing? Also in (b) and (c) which “median” are referred to here? All proxies median, tree-only or coral-only proxies median, median from Table 1 reconstructions? May you please clarify.

Section 5:

Some figure caption callouts appear to be incorrect e.g. Fig. 8a insert but I can’t see an insert for figure 8. Please check all the callouts in this section.

In all the relevant figure captions please use more useful terminology than ‘proxy 1’ etc. It was quite frustrating to be continually flipping between the figures and the table to work out what which record was which.

Finally, may the authors please add some more explanation as to why the MRV method works better than the RVM method.

Expand the discussion on limitations and possible caveats on applying the technique. For example, can the technique be applied to discontinuous records? For example can the technique be used with the types of data that come from fossil coral boulders (e.g. Cobb et al 2003, 2013)? What are the advantages and disadvantages of this technique compared to the other synthesis techniques listed on page 2940?

C1559

Summary and conclusions:

The authors discuss limitations of their technique and study, and implications for ENSO reconstructions – I feel this should be part of the discussion section, since they are important new points rather than summaries or conclusions.

Possible record to include in the single site synthesis:

Kelly A. Hereid, Terrence M. Quinn, Frederick W. Taylor, Chuan-Chou Shen, R. Lawrence Edwards and Hai Cheng. Coral record of reduced El Niño activity in the early 15th to middle 17th centuries. *Geology* 2013;41;51-54 doi: 10.1130/G33510.1

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