Clim. Past Discuss., 11, C553–C558, 2015
www.clim-past-discuss.net/11/C553/2015/

Climate of the Past Discussions

Interactive comment on "Stability of ENSO and its tropical Pacific teleconnections over the Last Millennium" *by* S. C. Lewis and A. N. LeGrande

Anonymous Referee #2

Received and published: 7 June 2015

Using climate models this study aims to provide cautionary in interpreting paleo proxies for ENSO, given its unstable teleconnection patterns through time. The community has been aware of the issue. With the currently limited availability of paleo samples a clear demonstration of the teleconnection complexity is needed and this can be achieved using climate models. This study would thus be a valuable addition to the existing paleo literature after several issues listed below are addressed.

This study utilises the ensemble mean of 6 CMIP5 models that have the required set of experiments. The authors argue that, while they acknowledge each model is not free of biases, model bias is not a prohibitive issue for investigating the temporal stability of teleconnections [p. 1588 (25)]. I tend to agree with this argument, but it is still important to provide an indication to what extent the multi-model mean (MMM) represents

the entire 6 samples. This is particularly necessary as model selection have not been extensively conducted, perhaps given the limited models available. Even one or two models could exhibit severe bias that may skew the MMM, especially in the climatology that can affect teleconnection patterns. A severe cold tongue bias for instance can spuriously shift rainfall teleconnection. In this case, rainfall in the western Pacific or Maritime Continent and the Nino3.4 could be positively correlated, while in reality or in more realistic models they should be negatively correlated. Averaging these teleconnections across models would result in a weak correlation as seems to be the case in Fig. 8. It would be a better approach to present the results for each model or present a confidence interval over each of the ensemble mean. For example, in Fig. 8 a confidence interval (or even better each model correlation value) should be added over the MMM.

Li et al. 2013 (see their Fig. 2) found that their paleo proxies in the west Pacific (Maritime Continent) and east Pacific generally correlate quite well with Nino3.4, in contrast to those suggested by Fig. 8. It is necessary to comment in Section 4.2 the possible reasons for this mismatch (e.g., due to certain model biases, as per above points). Also, it would be good to put the results of Section 4.2 in the context of other existing studies.

In light of the above comment, it is actually necessary for the readers to get a better sense in how each of the 6 models performs in terms of the ENSO characteristics and in terms of the mean climate. In section 3 (page 1587) it seems that the authors tried to do this: "Here, ENSO was examined through 6 metrics. . .." but there are no figures that show some of these metrics (e.g., seasonality, Nino3 vs Nino4 amplitude, etc). There are by now a number of studies evaluating the fidelity of ENSO simulation. In terms of climatological bias, at present the authors are comparing the multi-model-mean vs observations in Fig. 4 where climatological bias is severe. Perhaps one or two models are significantly contributing to the westward bias (e.g., IPSL-CM5A-LR, HadCM3, possibly the GISS-E2-R as well; see Taschetto et al. 2014 J. Climate, their

Fig. 3c). IPSL-CM5A-LR for instance cannot simulate the nonlinear response of rainfall to Nino3 SST anomalies that underpin extreme El Nino (Cai et al. 2014 Nature Climate Change).

Shouldn't HadCM2 be HadCM3? HadCM2 is an old model used in IPCC 2nd assessment report, definitely does not contribute to CMIP5.

The authors chose to use Nino3.4 to represent ENSO based on the similarity between the MMM of EOF1 surface temperature in historical and past1000 runs. However, this does not take into account the fact that the temperature pattern changes through time. At certain epochs (of say 30 years), Nino4 can better capture the predominant ENSO characteristics over that particular epoch (E.g., after the 90s – McPhaden et al. 2011 GRL; possibly mid Holocene – Karamperidou et al. 2015, Paleoceanography), and at other epochs, Nino3 could be better. Spatial changes in ENSO pattern are not discussed in this present paper, but it is an important aspect as far as teleconnection is concerned. This should be discussed to a certain extent in the manuscript. Section 4.3 for instance should mention recent results by Karamperidou et al. (2015 Paleoceanography) in which they used CCSM4 model that the mid Holocene involves a change in the spatial pattern of ENSO from eastern Pacific to central Pacific. See also Carre et al. (Science).

p. 1584 (5): Is it air temperature or sea surface temperature for the Nino3.4? It is also not clear how composites are calculated here. Is it for the 6 consecutive months or just annual mean?

Various studies (e.g.., Li et al. 2013) have used other locations more remote than those used in this present paper for proxy reconstructions. As the authors argue that it is important to link remote proxies with those in central Pacific, why not include far more remote regions as well (e.g., North Pacific, Central Asia) to better illustrate their argument.

Fig. 3: It's worth mentioning that the higher power at low frequency in the past 1000 yr

runs is also likely attributed to the much longer time series than the historical (30 yrs), better resolving the low-frequency variability.

P1591 (10), The first sentence implies variability in control simulations is similar to that in past1000, but the subsequent sentences contradict that. It would be easier to compare with Fig. 2 if the power spectra in Fig. 6 are computed using 100-yr samples. It is not clear whether the differences between the two simulations are due to the different length of time series.

p.1592 (20), the difference in the magnitude of the teleconnection patterns in Fig. 1 between past1000 and historical should more likely be due to the averaging of more samples in the past1000 simulations (compared with only 30 years in historical). Actually statistical significance can be added in Fig. 1 by constructing confidence interval based on 30-yr chunks in the past1000 across the 6 models. Do the same for the 30-yr historical. This will then allow determination whether the ensemble means between the historical and past1000 yr are significantly different.

Minor comments:

The line specs in Fig. 7 are confusing. Why are there 3 different colours for the fitted line? On the left panel the black lines seem to match the blue dots better, so I'm not sure which one is for which. I think Fig. 7 can be culled since the same information can be found in Fig. 8. The historical values can be added in Fig. 8 instead.

Again, what does Fig. 8 look like in each model? Insert horizontal lines indicating statistical significant level in Fig. 8.

This manuscript is well written but it could be shorter as there appears to be a lot of repetitions, e.g.,: p. 1592 (15) first, second, and third sentences basically convey the same message. It need not be stated three times, especially in the same paragraph. A lot of information stated in Section 2 is again repeated in Section 4 (e.g., p. 1593 (10)). P1587 (20, 25): "Models that have. . ...In addition, . . .The MIROC-ESM. . ..(Fig.3)" is a

long unnecessary repetition from Section 2 (page 1584). Could consider shortening Section 2 and integrate it to the other sections or move it to an appendix.

The literature review is lacking on ENSO behaviour response to greenhouse warming, and model-based studies on the sensitivity in the relationship between ENSO and background climate state (p. 1581). A number of recent studies beyond the Collins et al. 2010 (Nature Climate Change) have found that there is indeed inter-model agreement in the response of ENSO to greenhouse warming. Apart from the Power et al. (2013) paper, the other studies show that this response appears to be in the form of an increase in the frequency of extreme El Nino and La Nina (Santoso et al. 2013 Nature; Cai et al. 2014; 2015, Nature Climate Change). It would be good to mention these studies in the introduction to provide a more updated background literature. The model projected change toward more extreme ENSO occurrences under greenhouse warming can provide an interesting avenue for paleo studies to investigate.

1st paragraph on page 1581: "observed changes in the character of ENSO since mid-70s towards a dominance of El Nino" is not accurate, since late 90s the mean state has changed toward a La Nina-like (e.g., England et al. 2014, Nature Climate Change; Hu et al. 2013 J. Climate 26, 2601-2613).

Page 1589 on inter-decadal modulation of ENSO behaviour, one relevant paper is Borlace et al. 2013, J. Climate that demonstrate how this can arise naturally via vacillation of the internal ENSO dynamics.

Fig 1. : The Y-axis ticks do not look correct, and the western and central boxes are not centred about the equator.

P1584 (20, 25, etc.) "past 1000" should be "past-1000" or "past1000". Otherwise 'past 1000 simulations' could be mistaken as one thousand simulations in the past, while it should mean past 1000-yr simulations.

P1584 (25) Refer to Fig. S2 and Fig. . .. How about showing observations as well?

10 'categorised' should be 'categorise'

p.1585 (15), "experiments in was" delete 'in'

"For the GISS-E2-R (Schmidt et al., 2014) and IPSL-CM5A-LR (Dufresne et al., 2013) models. . .." It is better to insert these reference in Table 1 for all of the models.

Interactive comment on Clim. Past Discuss., 11, 1579, 2015.