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Interactive comment on "The Paleoclimate reanalysis project" *by* S. A. Browning and I. D. Goodwin

S. A. Browning and I. D. Goodwin

stuart.browning@mq.edu.au

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The paper proposes a method to reconstructed past climate that falls in the area between traditional proxy reconstructions and the emerging field of data assimilation. I find the paper incredibly interesting, and the "offline" method appears to offer a lot of potential benefits of data assimilation, while having minimal computational requirements. It is also relatively well written. I do however, have some comments that I think should be addressed and clarified in the manuscript before publication in Climate of the Past.

1/ line 13-14: "After assimilation the LME is highly correlated to almost all included proxy data, and dynamical relationships between modelled variables are preserved",

for the selected fields maybe, but this is not the case for the subtropical and polar ocean due to the long memory of the region. This caveat should be made clear in the revised manuscript. This comes up again on lines 13-15 of page 4164, and on lines 18-19 on page 4165.

We have attempted to address this comment, but it doesn't really make sense. Extratropical SST variability does influence terrestrial proxies–especially in terms of temperature, hydrology and atmospheric circulation–therefore the state of the extratropical SST fields should be correctly resolved. Logically, extratropical SST fields should be interpreted with most confidence in regions constrained by extratropical SST proxy data.

2/ line 25, page 4162: seems like the ideal place to redefine the temporal resolution that is being reconstructed.

The temporal resolution of PaleoR is determined by the temporal resolution of the proxy data, for this reason the resolution to be reconstructed is discussed in the proxy data section.

3/ line 5, page 4163: "Proxy data of varying temporal resolutions are accommodated, including records representing discrete time periods". How are annual and multidecadal resolution records accommodated? Are simply linearly interpolated (yes according to line 12-13)? If so the above statement is not exactly accurate.

No linear interpolation of any kind is employed in the production of PaleoR, and lines 12-13 certainly do not mention or imply this. There is no need to linearly interpolate multidecadal resolution data when we are reconstructing time periods at multidecadal resolution. As explained in Section 2.1 we can produce variable resolution reconstructions by adjusting the resolution of each time period to suit the lowest resolution data. Therefore, where we use multidecadal scale data (or data with multidecadal scale dating uncertainties) we reconstruct multidecadal length time periods–annual or decadal data are coarsened to multidecadal means. Because each time period (whatever the

CPD
11, C2503–C2508, 2015

length) is reconstructed independently we can also include data representing discrete time periods. This is all clearly and correctly stated in Section 2.1 so we do not feel any modification of the text is required.

4/ line 3-5, page 4164: From experience, the longer time period that is averaged, the more the spatial detail is smoothed. The fact that decadal averages are used for the paleo climate data, while annual averages are used for the model suggests that the model fields have a lot more spatial variability than would be expected from the proxies. I tend to think that this average time discrepancy could allow the proxy data to be overfitted? Why do the authors not use decadal averages, as the use of a sliding window (as was done here) means that it would not have a great deal of impact on the number of available analogs.

It would be certainly possible to run a 10-year smoothing through the model data prior to assimilation and is something that might be worth exploring in future versions, with the current version used as a baseline. However, were not convinced this would benefit the representation of each time period, as each time period is already represented by the mean of 50 BMA years, so there is already considerable 'smoothing' of the signal, without adding more noise.

5/ Line 7-8, page 4164: It is not clear to me what is meant by "to account for seasonality, annual means are calculated from the seasons of proxy sensitivity". Are you suggesting that in some locations only seasonal averages are being looked at? If so how where the seasons specified and did they vary depending on proxy type and location?

Most proxy records are strongly sensitive to seasonality. For example, some trees only grow during the summer season. We therefore calculate the value (e.g. temperature anomaly) for each year of the model simulation based on the seasonal sensitivity of the proxy data. In most cases seasonal sensitivity is published along with the original proxy data, so we use the original published interpretations. Where no information is available we have attempted to determine this sensitivity ourselves by running multi-

CPD

11, C2503–C2508, 2015

ple seasonal correlations with the observational record and choosing the best match–provided there is a plausible physical mechanism to support the observed correlation. We have modified the wording of this sentence for clarity: "to account for seasonality, annual values are calculated from the seasons of proxy sensitivity".

6/ line 12, page 4165: "ensemble spread provides one estimate of uncertainty." But is unclear how the error bars calculated in figure 4 are calculated, are they representing the 5th and 95th percentiles of the indices calculated from the 50 BMA?

The caption for Figure 4 states that "Shading on PaleoR timeseries defines the 95% confidence interval of the 50-member BMA ensemble mean at each timestep". In response to this comment we have added text to page 4165 to clarify that we are using a Student T-test to calculate the statistical significance of the 50 BMA. A more detailed discussion of uncertainty estimates has also been included in the revised manuscript (Section 4.2) in response to this comment and similar comments from Referees 1 and 3.

7/ Section 2.4.2. Are ten year averages of the pseudo-proxies used, while annual averages of the LME model are used for the analogs?

This is correct, as stated in Section 2.4.2, the setup for the pseudoproxy experiment is the same as described in Section 2.3 where it is applied to real proxy data.

8/ Section 4. I understand what is meant in the initial discussion of section 4, but surely there should be some best version that uses all available proxies, then the tool can be used to back out the importance of individual proxies of various regions and look for robust responses etc. . . . This also comes out again on line 6, page 4176, and raises the thought of waiting for the next iteration? Rewording in both places will help clarify the intended message. Maybe the authors should highlight regions that they are confident in the current PaleoR and dont expect to change a great deal in future iterations?

CPD
11, C2503–C2508, 2015

As stated several times in the manuscript, this article describes our progress to-date, and we expect to see significant progress in paleoclimate-based reanalysis in coming years. This includes improvements in model simulations, assimilation schemes and proxy data coverage and interpretation–all these points are discussed in Section 4. To the best of our knowledge there is no existing compilation containing "all available proxies"; producing such a dataset would be a huge undertaking. Pages 2K have been working toward this objective for many years and their phase 2 temperature proxy dataset is soon to be released. However, even this dataset does not come close to containing all available proxies. We have been working closely with Pages and plan to incorporate the Pages 2K phase 2 dataset into the next version of PaleoR. However, we are not willing to simply 'plug-in' the dataset and run PaleoR. Each record needs to be individually evaluated to ensure it is correctly represented in terms of its seasonality and calibration to modeled climate variables. With over 900 records in the Pages 2K phase 2 dataset, this is a non-trivial task. The current PaleoR version contains a reasonable spatial distribution of published proxy data in which we have relatively high confidence; it therefore provides a good starting point from which to expand the proxy network in future versions. We strongly disagree with the proposal to start with a large dataset and work backwards. In our opinion, it is better to start with a smaller set of proxies in which we have high confidence, and then incrementally add more records to see how they fit with the existing network. As with most products in science, and society in general, the next iteration tends to bring improvements. Our rationale is that it is better to put this product out for evaluation and discussion amongst the paleoclimate community in its present form, so we can incorporate feedback, suggestions, and new data in future versions–hence our decision to publish in CPD. Publication and community participation also provides justification for the significant resources required to continue development of PaleoR. The regions in which we expect to see improvement are logically those locations where proxy coverage is limited. These regions correspond to areas of low correlation scores in the Pseudoproxy experiments (Figure 3). We agree that it is worth including a statement to this effect in Section 4.3.

CPD

11, C2503–C2508, 2015

9/ line 11, page 4174: the realistic forcing of LME, this is definitely one of the aspects that makes this model so useful for the PaleoR analysis, the fact that it includes changes in solar and volcanic forcing and the fact it had a large amount of ensemble members. If this really is a tool to be used as described above, the authors should define/discuss how many analogues are required to generate an accurate reconstruction and what forcings they believe the source model should have. Is the LME the best model choice here?

This question is somewhat arbitrary; we have used the largest and most realistic ensemble we have access to. The question would become relevant if we were setting out to run our own set of simulations and needed to minimize costs by running only as many simulations as needed.

Interactive comment on Clim. Past Discuss., 11, 4159, 2015.