

## ***Interactive comment on “On-line and off-line data assimilation of palaeoclimate proxy data into a GCM using ensemble member selection” by A. Matsikaris et al.***

### **Anonymous Referee #2**

Received and published: 18 September 2014

#### General comments:

The paper presents a comparison of two closely related on-line and off-line data assimilation approaches in paleoclimatology. This is – to my knowledge – the first study that has specifically addressed this problem. The authors find very little difference between the two methods in large-scale metrics and conclude that either their assimilation approach offers too little control of the slow components of the climate system (the ocean) or there is very little information propagation on decadal timescales. Due to the specific choices of the approach and due to the wide range of alternative choices (and approaches), the conclusion drawn in the paper may not apply in general. Nevertheless, the manuscript offers a valuable starting point for further discussion.

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The manuscript is generally well written, but there is quite some redundancy in the discussion and presentation of the results. Also a few issues require further attention (see comments below). Therefore, I suggest to accept the paper with major revisions.

#### Lack of information propagation

The authors argue that the similarity of the on-line and off-line approach points to either a lack of control of the slow components, or a lack of information propagation on decadal scales in the model. While the first hypothesis is impossible to test without additional data (that may not exist), the information propagation on decadal timescales could be tested. In the on-line assimilation all ensemble members are initialized with the same ocean state at the beginning of each decade. Therefore, if there is information propagation, one would expect less spread in the on-line ensemble at the end of the decade than in the off-line ensemble (starting from different ocean initial states). I strongly suggest to analyze and discuss this and the consequences in the paper. To be able to better interpret the similarity between the on-line and off-line approach might greatly strengthen the conclusions drawn from this paper

#### Uncertainty analysis

Sampling effects may affect many of the aspects discussed in the study due to the limited ensemble size and relatively short time period analyzed. Therefore, sampling uncertainty should be more thoroughly addressed where possible. For example, re-sampling might be used to illustrate the distribution of skill metrics (correlation, rmse) when randomly sampling a best model in the off-line method. This may help to interpret the significance of the differences between the on-line and off-line method. Also a resampling approach could be used to illustrate the dependency of skill of the off-line ensemble member selection on ensemble size (i.e. from 1 to 10 members) instead of justifying ensemble size based on a study with an atmosphere-only GCM (.

#### Redundancy in presentation and discussion of results

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I strongly urge the authors to shorten the presentation and discussion of results in the manuscript. This concerns in particular the presentation of results in figures. Figure 3 and 6 for example could be summarized in one figure with the spread in ensemble results represented by a bar (or boxplot), and the ensemble mean and analysis as symbols for both the on-line and off-line ensemble. Similarly, Figures 1 and 5 might be superimposed (replacing the individual simulations with shading for the range of the different ensembles). In my opinion, superposition of the results of the on-line and off-line approach would be highly beneficial to the reader as the main point and novelty of the manuscript is the comparison of the two approaches. Therefore, the results should also be presented in a way that facilitates this comparison.

Similarly the discussion of the RMSE and correlation of the individual approaches may be reorganized to better reflect the similarity of the methods and focus more on the comparison while at the same time improve readability.

#### Specific comments

Title: The title is a bit long and very specific. Maybe “On-line and off-line data assimilation in paleoclimatology: a case study” or something along those lines could help to shorten the title.

P3451L11+: Large-scale and spatial field reconstructions are contrasted without motivation why this is relevant for the manuscript. Please clarify.

P3451L15and22: errors vs. uncertainties. Please either clarify why you use different terms to describe model and proxy errors/uncertainties or use the same term twice.

P3451L14+: Please add references to substantiate the specific limitations of proxy series mentioned in the following two sentences.

P3452L19+: The authors mention that Goose et al. have performed on-line and off-line data assimilation already. Please clarify that the novelty of this manuscript is the focus on the comparison of the on-line and off-line approach.

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Comment

P3453L6: I do not fully understand the meaning of involved in this sentence. Do you want to say that the off-line assimilation is difficult to apply or that the method of Annan and Hargreaves is and off-line assimilation based on a simple likelihood weighting algorithm? Please reword.

P3454L10: First mention of decadal, please better motivate why multi-yearly (decadal) is important for climate reconstructions. If proxies with yearly and seasonal resolution are available for assimilation, long memory (as in decadal) may be less important.

P3454L13: Please provide reference for 'up to decadal predictability in the North Atlantic'

P3456L4+: I would love to see evidence (a figure) of the growth of ensemble spread in ocean variables such as AMOC. Understanding of how quickly the ensemble diverges would also help the readers to better understand the particularities of the DA method (see general comment on information propagation).

P3457L6: is the 10 to 30-year resolution of the North American proxy reconstructions the reason for the experiment design with decadal assimilation?

P3458L14: double negative, please rephrase.

P3459L15+: Consider moving the first two paragraphs to the introduction and methods sections to improve readability as these are clearly not your results.

P3460L15: I suggest to add a table with correlations for the different experiments (as for rmse) to simplify discussion and comparison.

P3461L13: please indicate the range of the correlation for the individual proxies (maybe also in table).

P3461L23+: This is not true. The lower RMSE of the ensemble mean is simply due to the lower variance of the ensemble mean (Annan and Hargreaves, 2011). If you were to find that the ensemble mean is more highly correlated with the proxy series

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than most of the individual members then you might argue to find evidence for the importance of forcing.

P3462L1: as presented above.

P3463L11: on the basis of

P3463L11+: If you mean “is not expected to be more skillful than ALL the individual members” this may be true, but maybe beyond your point. I would disagree with the general statement, however, as we expect the analysis to be more skillful on centennial, hemispheric scales even if we train the analysis with decadal, continental data (not least due to dependence of the continent and hemispheric averages).

P3464L13: insufficient control of the ocean state only affects the on-line method. The off-line method is an a posteriori selection for which the ocean state is irrelevant (as long as the ensemble is sufficiently large).

P3464L6: missing period. 1640-49 AD.

P3465L1: We know whether the ocean has predictability in this experimental set up (see general comments).

P3473: Please specify what the dashed (dotted) grey lines mean. Also please consider moving to a standard line plot to be able to better differentiate the lines (if you decide to show all the individual members, see general comments).

P3480: Please use different symbols to distinguish the ensemble mean and analysis from the individual members (and see general comments on presentation).

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Interactive comment on Clim. Past Discuss., 10, 3449, 2014.

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