



EGUsphere, referee comment RC2
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Comment on egusphere-2022-184

Anonymous Referee #2

Referee comment on "Reconstructing Holocene temperatures in time and space using paleoclimate data assimilation" by Michael P. Erb et al., EGU sphere,
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Erb and colleagues provide a new global temperature reconstruction covering the Holocene by combining available paleoclimate records from the Temp12k database and climate model simulations using a data assimilation method. Such a reconstruction is particularly relevant since proxies only provide information at the local scale and can suffer from seasonal biases. The paper is pleasant to read and most choices are well justified. This study is likely suitable to be published in *Climate of the Past* after considering my following comments - I have no major comments.

- In comparison with Osman et al., continental records are also included in the data assimilation. What is the contribution of these additional records to the reconstruction? In other words, how much of the signal in the global reconstruction comes from 1) ocean records and 2) continental records?
- The Southern Hemisphere contains far fewer records than the Northern Hemisphere. Do you have any clues on the potential impact on global reconstruction?
- The authors chose to work in temperature space by converting all proxies to temperature, but in recent years an increasing number of proxy system models have been published. For example, in Osman et al. such models are used. In my opinion, using more sophisticated PSMs is the way to go to improve reconstructions since proxies are not only temperature-sensitive. I understand that this is a heavy load, but the authors should at least discuss this point – for me, this is the main caveat of the study.
- In the method section, it is said that all the proxies (initially at the decadal resolution) are interpolated annually, then binned into the decadal mean. I don't understand why this is necessary. How does it impact the DA results? For me, this may introduce noise, which could ultimately explain the small variance compared to other DA-based reconstructions (e.g. Osman et al.).
- The model outputs were interpolated on a $2.8125^\circ \times 3.75^\circ$ grid. Could you please justify this choice?
- The authors strongly insist on the relevance of the multi-timescale approach in several places. Could you please quantify the added value of using appropriate multi-timescale covariances? I would say that such an approach is needed when performing a data assimilation experiment with annual and decadal (or even lower) records to keep the

memory of the ocean, but I am wondering if this multi-timescale approach is really needed here because you have assimilated 10-year and lower resolution proxies.

- As noted by the authors, annual reconstructions could be biased due to seasonality. In the method section, the authors should explain better how they deal with this to finally produce an annual reconstruction – there are a few words in the results section but it should be clearly mentioned in the method section and in more detail considering its crucial importance.
- In the discussion section, the authors mention that the marine sediments used in Osman et al. are also used in their reconstruction. To better understand why there are differences between your reconstruction and Osman et al., assimilating only those records into your data assimilation scheme would be very useful (e.g. the two reconstructions are based on different methods, albeit similar). It would also be an opportunity to quantify the contribution of marine archives in the final reconstruction (see my previous comment), and to quantify the use of PSMs.
- Proxy uncertainty plays a major role in the final DA-based reconstruction because it determines the weight given to each proxy record in data assimilation. The lower the proxy uncertainty, the higher its contribution. The authors performed an additional reconstruction by decreasing the proxy uncertainty by 20%. In order to know if the proxy uncertainty has been correctly estimated, some indicators on the size of the ensemble exist, for example, ECR or CRPSS. Quantifying the ensemble size for all analyzed reconstructions could help to better understand the differences between the reconstructions and may explain why your reconstruction has a reduced variance compared to Osman et al. reconstruction.
- Although somewhat out of scope for this study, I encourage the authors to also provide atmospheric circulation reconstruction (e.g. sea level pressure, 500-hPa geopotential heights).