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Climate of the Past Discussions

Interactive comment on "Methodological and physical biases in global to sub-continental borehole temperature reconstructions: an assessment from a pseudo-proxy perspective" *by* Camilo Melo-Aguilar et al.

Anonymous Referee #2

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The paper uses a set of Earth System Model (ESM) simulations, with different initial conditions, to synthetically generate borehole subsurface temperature anomalies in in order to assess the methodological issues that may affect the reconstruction of ground surface temperature changes during the post-industrial period (1850-200 CE).

The premise here is that the ground energy content and its subsurface temperature field respond to the energy balance at the ground surface. Such balance is interplayed by a series of physical and biological processes, hydrology, hydrogeology, vegetation response, land use, etc. However if such physical and biological processes do not vary

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over long time scales (decades to centuries), then the impulse response relation between surface air temperature and ground surface temperature should remain constant at long-time scales, thus surface air temperature changes should be reflected in ground surface temperatures mediated by an offset. By measuring vertical temperature profiles, subsurface temperature anomalies can be analyzed and interpreted as changes in the ground surface temperature as a response to surface temperature changes.

General Comments.

The paper is a meticulous set of synthetic experiments within a climate model space that uses the model reality to generate the data on which the experiments are carried out. That is, the input and output of the signals to be analyzed are know thus results are expected to be self-consistent and provide for the perfect pseudo reality in which experiments can be performed under controlled conditions.

The methodological approach for assessment of the impulse/response analysis are sound and well tested by the borehole reconstruction community and this paper represent a valuable contribution to the subject and to Climate of the Past.

I have several comments that I hope are useful. Some of my suggestions are outside the scope of the paper and I only mention them as suggestions for future work.

- The main issue for me, as the authors mention in the last part of the conclusions, is that all experiments are done in a noise-free environment. Data noise in borehole climatology is extremely important as it has an important effect on the maximum resolution that real data can provide. I assume that the authors are planning a second paper where the methodologies are explored in data and noise environment. I would encourage such paper.

-The authors examined the reconstructions based on (noise-free) subsurface temperature anomalies and not from complete borehole temperature profiles as these data are acquired.

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Minor issues:

The paper is very dense requiring a lot of effort to keep up with the acronyms.

Line 36. A reference is needed for this claim.

Line 56-57. Depth of borehole temperature profiles was examined in Beltrami et al., 2011. A correction for logging time differential was used in Jaume-Santero et al., 2016.

Line 69: delete word “global”

Line 206. Convenient is misspelled.

Line 210: In the noise-free case presented here, the set up of the inversion depends on the choice of model, the geometry of the problem (i.e. the depth of the temperature profile and the depth sampling rate). The sampling rate is not given in the paper. I have assumed it was 1 m.

In practice, the number of eigenvalues retained in the inversion are also -besides the above mentioned factors - heavily determined by the noise level in the measurements. The tests with four and five eigenvectors retained thus do not have a straight forward meaning as in practical term the noise level would determining the number of principal components retained in the ground surface temperature reconstruction.

Section 3.2 (Pseudo) pseudo-proxy. The pseudo-proxy data generated here consist of subsurface temperature anomalies, not borehole temperature profiles (BTP). The BTP is a superposition of the subsurface temperature anomaly on the quasi-steady state temperate gradient. Perhaps authors should use BT anomaly (BTA).

Line 240 on: I am confused regarding the generation of the subsurface temperature anomaly field:

“Once the spatial distribution of the borehole network is represented in the CESM-LME grid, the LM STL12 series at each of these grid points is trimmed at the actual logging date according to the date distribution (Fig. 1a). Then, the temperature anomalies are calculated with respect to the trimmed period mean" .

Does this mean that each "trimming period mean" or the "trimmed period" is used as a reference to estimate the anomalies? If so, in either case, each anomaly would have a different reference which could complicate the interpretation. In fact, they should take a single common period to estimate all anomalies for the comparison with the IBS case. Then verified that the differences on trimming period means may have something to do with the differences between the red and green inversion results in Figure 2 a.

In addition, how is the varying number of boreholes accounted for in the last 30-40 years for the green curve in Figure 2a?

Is the number of BT anomalies for IBS-L12 and B-mask the same in the most recent two inversion steps?

Do subsurface temperature anomalies in the IBS extend to the surface or to 7.8 m (node 12)? Real borehole temperature measurement standard analysis use data below 15-20 m?

Line 273: From Figure 2a, it is not clear to me that the temperature anomaly reconstructions capture the MCA-LIA transition. It seems to me that the resolution was lost by 1850 CE. The next sentence in line 273-274 seems to mention this but it seems contradictory.

Line 276: "Nevertheless, in model experiments that simulate larger MCA LIA changes the borehole reconstruction is able to recover somewhat warmer temperatures during the MCA (González-Rouco et al., 2006, 2009)." This would depend on the depth of the anomalies and also the number of principal components retained.

Line 346 and Lines 573-574 "The variability of the depth of the borehole records..." This is so only because the work is based on the analysis of subsurface temperature anomalies that contain little signals below 200 m because of the character of the ESM output used here.

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Line 370 on, including Figure 3: The number of boreholes in Africa is small, and the area is huge. Much larger that the European slice in Fig 3b. Perhaps, giving the number of sites per unit area may help assess the discrepancies. The red and green lines in Fig 3c, seem contradictory for the cases shown. Are these differences arising from the different initial conditions of each of the 13 simulations? I wonder again whether the referencing over the trimmed period may have something to do with this (see comment on line 240.

I wonder what are the SAT-SAT mask) differences from the ESM simulations?

Line 632-633 : I would like the authors to expand in this issue. Perhaps, there is a need systematically collect additional borehole temperature profiles.

Summary and suggestions:

This is a good paper worthy of publication in COP.

Although out of the scope of this paper:

- It would be worth examining this problem for other ESM's simulations.

- I would also suggest that the authors consider writing a follow up paper with an identical analysis as in this paper, but based on a set of artificially generated full temperature logs, including simulated data noise. It may be that many of the differences that they observed in the noise-free set of experiments may change; and some differences could potentially be blurred significantly.

References:

Beltrami, H., J.E. Smerdon, G. Matharoo, and N. Nickerson (2011) Impact of maximum borehole depths on inverted temperature histories in borehole paleoclimatology, Clim. Past, 7, 745-756, 2011.

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