

Geosci. Model Dev. Discuss., referee comment RC2  
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## Comment on gmd-2022-178

Anonymous Referee #2

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Referee comment on "A new bootstrap technique to quantify uncertainty in estimates of ground surface temperature and ground heat flux histories from geothermal data" by Francisco José Cuesta-Valero et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2022-178-RC2>, 2022

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In this article, the authors introduce a new technique to estimate ground surface temperature and ground heat flux histories. Using an artificial temperature profile and real data from the Xibalbá subsurface temperature profiles, they show how this new technique performs against the tested singular value decomposition and perturbed parameter inversions methods. Little difference is noted when examining individual profiles. However, notable differences in the uncertainty range for the inversion of large sets of subsurface temperature profiles are observed with the new bootstrap technique producing smaller uncertainty ranges.

The authors clearly explain the importance of these various methods and shedding light on the thermal state of the land surface. They elaborate the three different methodologies and provide useful figures to illustrate their points. I found Figure 2 to be especially helpful. I believe that the outlined new methodology is a useful new tool for the community and would recommend publication after some minor changes.

Comments:

There is little discussion in the data section as to the uncertainty associated with the proxy-based temperatures and the Xibalbá subsurface temperature profiles. Are there errors associated with converting the PAGES2k global temperatures to a land temperatures? With respect to the Xibalbá subsurface temperature profiles, they haven't all been measured at the same time. This will influence the reconstruction. I think a couple of lines here elaborating these uncertainties could be helpful. It would also help the reader further understand the complexity of undertaking these inversions as the data is not perfect and that any tool that can minimize uncertainty is important.â□"

On L153 and later in Section 3.8, the authors state how the continental subsurface is considered homogeneous (i.e. thermal properties are constant) and give the example of the Arctic. However, I cannot believe that the Arctic could be considered representative of the globe. How can one consider a constant thermal diffusivity and conductivity for all regions? Is this an unfortunate trade off due to the lack of subsurface thermal data?

On L418, the authors state: "Another remarkable results is the agreement between the PAGES2k land temperatures and the ground surface temperature histories for most of the period." While this appears to be true for a quick glance at Figure 7, notable differences can be seen when examining Table 2. The three methods reconstruct a warming about two times greater in 1950-2000, 1900-1950, 1850-1900, and 1800-1850. The authors do note this following L418. However, I believe this sentence should be rephrased to emphasize the how the tendency is captured but not the magnitude and/or highlight the excellent job the methods do in reconstructing the period of 1600-1800.

In Figure 8b, PPI and BTI with varying  $\kappa$  and  $\lambda$  show an increase in heat flux as of about 1970 that is not observed in SVD nor PPI and BTI with constant  $\kappa$  and  $\lambda$ . This is not elaborated in the text. It would be helpful to a reader to have a couple lines clarifying this.

Technical Points:

L51-52: Should read: "Nevertheless, several sources of uncertainty arise in the inversion process, the most important being..."

Overall, watch the use of "consists in" in the text. For the majority of time used, it should actually be "consists of"

L59-60: Should read: "...the deepest part of the observed profile, then providing a best estimate..."

L101: "These experiments also allow to identify..." should read "These experiments allow for the identification of..."

L153: Should read: "...typical vary by a relatively small..."

L196: Should read: "Finally, small eigenvalues are from S-1 in order to stabilize the solution..."

L204-205: Should read: "The errors in the estimates of the long-term surface temperature ( $T_0$ ) and the geothermal gradient ( $\Gamma_0$ ) have ..."

L251: Should read: "As explained in the Introduction, the SVD and PPI techniques do not provide a comprehensive..."

L263: "...which are retrieved from..." should be "which are retrieved from..."

The units of thermal diffusivity are shown as  $m^2s$  but they should be  $m^2s^{-1}$

L394: sensible should be sensitive

L433: "This three factors..." should be "These three factors..."

In Table 1, please define  $N_s$  and  $N_B$

In Figure 3, the shading associated with the purple line isn't purple but blue. For consistency with the other figures, I recommend using the same purple shading colour as the other figures.

In the title of Figure 4, I would clarify that B in the title stands for Bootstrapping.