**Thank you for your thoughtful and constructive feedback. Here we provide a complete documentation of the changes made in the manuscript in response to each of your comments. Reviewers' comments are shown in plain text, while author responses are shown in bold green text.**

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.

**We have explained how the uncertainty of the PAGES2k temperature series is transformed for the PAGES2k-Land temperatures, and we have expanded the description of the Xibalbá profiles in the new version of the manuscript including the points raised by the reviewer.**

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?

**Indeed, only a few temperature profiles provide information about the thermal properties of the subsurface. However, the logs including information about thermal properties, like the example cited in the manuscript, show variations with depth around a mean value, thus the assumption of an homogeneous medium is reasonable. Furthermore, changes in subsurface thermal properties incompatible with an approximately homogeneous subsurface would appear in the recorded temperatures as a non-climatic signal, and such log would not be used in the analysis as explained in Section 2.2 of the manuscript. It is also worth to mention that the Xibalbá database excludes temperature records above $20 \, \mathrm{m}$ of depth, thus we only consider temperature measurements in bedrock. Therefore, the factors accounting for the largest variations in thermal properties, such as soil texture and composition, as well as soil moisture changes, are not relevant for the inversions. For these reasons, we can safely consider the subsurface as an homogeneous medium. We have tried to clarify this in the new version of the manuscript.**

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.

**We agree that speaking in terms of trends is more accurate in this context, we have modified the text accordingly.**

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.

**Figure 8 does not show surface temperature histories nor heat flux histories, but the uncertainty ranges in temperature and heat flux histories. In any case, the reviewer is right, the effect of varying thermal properties in Figure 8 is not discussed on the text. In fact, this effect does not affect the conclusions drawn from the results displayed in this figure, and therefore we have removed the lines that are not strictly required from the figure.**

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 (T0) 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 form…" should be "which are retrieved from…"

The units of thermal diffusivity are shown as m2s but they should be m2s-1

L394: sensible should be sensitive

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

**We thank the reviewer for taking the time to annotate all these issues. We have reviewed the text and have addressed all points.**

In Table 1, please define Ns and NB

**We have defined these parameters in the new version of the manuscript.**

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.

**The color of the SVD shading looks different in Figure 3 than, for example, in Figure 5. Nevertheless, this is not because different colors are used for the SVD shading in these figures, but**

because the order in which the shadings are drawn is different, affecting the displayed color. For example, Figure 6f shows that the shading of the SVD line is purple when drawn alone, but if drawn before the PPI shading, it looks as a markedly different shade of purple. Please, note that we change the drawing order to facilitate the interpretation of the figures, since the final color scheme if we follow the same drawing order in Figures 3 and 5, for example, would not provide the same level of detail. We could also change the colors used in the figures, but this will not solve the problem with the drawing order, and we would be using different colors to represent the same thing across the figures. We tested different colors and drawing orders, but we think it is best to keep the same colors though the entire manuscript, although the final colors of the shadows in Figure 3 seem different.

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

We have changed the "B" in the figure title by "bootstrapping" in the new version of the figure.