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Solid Earth Discussions

Interactive comment on "Heat-flow and subsurface temperature history at the site of Saraya (eastern Senegal)" *by* F. Lucazeau and F. Rolandone

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This is a well-written manuscript, dealing with the geothermal interpretation of eight new boreholes in the Sahel zone in western Africa. This includes both, the estimation of heat flow densities, as well as the reconstruction of recent surface temperature changes (back to the 18th century). The new data published in this article are located in a region where only very few measurements are available, and thus make it valuable in its own right. The inversion method large represents the state of the art, introducing some interesting ideas about the inclusion of local hydro-geological conditions. The description and discussion of the approach, however, should be enlarged to include some important aspects necessary to judge the results. Altogether this is an interesting and useful paper, but can be published only with *major revisions*.

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General comments

I think, this article could be improved in several aspects:

1. The borehole measurements are very shallow (< 250 m). However, there is a paleoclimatic effect of earlier temperature changes (mainly related to the last glacial-interglacial temperature rise) even at these depths (see, e.g., Rath et al., 2012). I'm not acquainted with African paleotemperatures, but if this can be neglected (see, e.g., Clark et al., 2012), it should be mentioned, and if not, the possible effect should be estimated. At these shallow depths this fortunately mainly concerns the estimate of the local basal heat flow, and thus does not influence the conclusions about the ground surface temperature histories. There might be an influence on the heat flow estimates.

2. I think there is some important information missing regarding the inversion procedure. Even if known to many, a few lines of theory might be helpful to the reader. In particular:

   - How is the ground surface temperature history parametrized - constant time steps or logarithmically decreasing? Can a change in parametrization reduce or even eliminate the mentioned inversion artifacts (Figure 4)?
   - Explain the cutoff f : is this referred to raw or normalized singular values? How is this value chosen?
   - What about the uncertainties?
   - Which MC procedure is used, e.g., how many samples, and which prior distributions were assumed?

3. The treatment of the effects of fluid flow is very interesting,and critical to the estimates of past ground temperature changes. If flow is included, you need a

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conceptual model for the system. A sketch might help the understanding. You included the additional assumptions on the influx temperature (set to T_s), and its vertical extension (20 m to 20 m). This seems to me reasonable to me. Though there are of course a lot of equivalencies involved, it might be interesting to include the influx temperature independently into the MC procedure. Some additional questions:

- In Table 2 you show the vertical velocities between 30 m and 50 m depth. What is assumed below 50 m? Is V_z the same? If not, where does the water come from or go to?
- Where do the estimates for horizontal flow come from in the cases where data above 30 m were not available(Table 2)?
- How can you differentiate between positive and negative values for the horizontal velocity?
- Are there any estimate estimates of porosity or permeability available?

Particular comments

- *Equation 2 and Figure 2*: From my understanding the common RMS should have the $\frac{1}{n}$ term below the square root. However in inverse literature some other measures of deviation are used (Aster et al., 2005), sometimes under the same name. Depending on what you can assume on the structure of your observation errors, the choice of the RMS may be reasonable for the misfit measure.
- *Figure 4:* The inverse procedure parametrizes the ground surface temperature history as a series of step functions. I think it should be shown in this form, and not as a smooth curve. This would also make the character of the inversion artifact clearer.

References

Aster, R., Borchers, B., and Thurber, C.: Parameter estimation and inverse problems, Academic Press, San Diego, 2005.

Clark, P. U., Shakun, J. D., Baker, P. A., Bartlein, P. J., Brewer, S., Brook, E., Carlson, A. E., Cheng, H., Kaufman, D. S., Liu, Z., Marchitto, T. M., Mix, A. C., Morrill, C., Otto-Bliesner, B. L., Pahnke, K., Russell, J. M., Whitlock, C., Adkins, J. F., Blois, J. L., Clark, J., Colman, S. M., Curry, W. B., Flower, B. P., He, F., Johnson, T. C., Lynch-Stieglitz, J., Markgraf, V., McManus, J., Mitrovica, J. X., Moreno, P. I., and Williams, J. W.: Global climate evolution during the last deglaciation, Proceedings of the National Academy of Sciences, 109, E1134–E1142, doi:10.1073/pnas.1116619109, 2012.

Rath, V., González-Rouco, J., and Goosse, H.: Impact of postglacial warming on borehole reconstructions of last millennium temperatures, Climate of the Past, accepted, doi:10.5194/cpd-7-3325-2011, 2012.

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