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The Cryosphere Discussions

Interactive comment on "Borehole temperatures reveal a changed energy budget at Mill Island, East Antarctica over recent decades" *by* J. L. Roberts et al.

Anonymous Referee #2

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Roberts and others provide interesting findings on ground surface temperature reconstruction using borehole temperature profile measured at Mill Island. The conclusions are drawn from numerical modeling of the inverse diffusion/advection problem. The main conclusion of the paper is that changes in the surface energy budget occurred around 1980/1981 AD +-5 years. I suggest to make it a bit stronger by continuing on why it is important to know or what knowing of that will tell us in a global scale. The introduction needs more elaboration towards the end of the section on what has been done in order to understand when the sudden increase in observed ground temperatures occurred. Numerical Model requires a better explanation on the forward model setup (more detailed explanation on initial and boundary conditions). Inverse

model needs to be changed to Inverse methods. This section needs major elaboration including formulas for the minimization functions used in both methods. In Surface temperature reconstruction section it is important to address how the initial temperature distribution is going to affect the reconstructed ground surface temperatures. The discussion section is well written, but I would suggest to include the insulation effect of fresh snow on the ground heat exchange budget. Overall, I recommend this paper for the publication after major revision.

Section 1 Introduction

In the introduction section the authors should further elaborate on what exactly has been done to fill the knowledge gap on the past borehole temperature increase. What inverse method/s was/were used? (brief description of the method/s). Why the specific inverse method/s was/were chosen? Have the methods been employed in similar studies before?

L13. It would be nice to have an entire map of Antarctica with the study site on it, where Fig 1 can be zoomed in a photo of the bigger map.

Section 2 Temperature observations

p 2577. L 20. What is a network of East Antarctica sites? Needs a reference.

p 2578. L 2. Reference is needed after Leeds and Northrup resistance bridge.

P 2578. L7. Remove the sentence "Temperature reading are shown in Table 1". I suggest to make a figure plot (y-axis depth, x-axis temperature) instead of Table 1 and make a reference to the figure.

P 2578. L10. Remove the sentence "The observed temperature distribution in the borehole is shown in the Table 1".

p 2578. L16. It is not very clear why the upper three measurements are discarded? I suggest to add more sentences on how the model is going to be driven if the upper

TCD
6, C1401–C1404, 2012

three layers neglected.

Section 3 Numerical Model.

P2578. L20 How the surface temperature history was assigned if the upper 3 layers had been discarded? I suggest to elaborate more on this section with more detailed information on boundary and initial conditions set up for the forward model.

P2579. L5 (See Sect.6 for nomenclature). Since the nomenclature is not too long it would be good to move it after the equation (1).

P2579. L6 The authors started from describing the last term. I suggest the description of the first two terms be included as well (diffusion and advection). What do coefficients in the second term stand for?

P2579. L11 It is not clear what the lower and the upper bounds are.

P2579. L15-16 Could the data be fitted with a simpler function?

P2579. L18-22 Where does the input data come from? What dataset have been used to force the model? I suggest the last paragraph in this section be moved (P2580 L8-12) after this paragraph.

P2579. L23 Why is the resulting reconstruction of the surface temperature history independent of the assumed velocity profile?

Section 3.2 Inverse Models. Change to Inverse methods.

Subsection 3.2.1 LSQR reconstruction. Change to LSQR method. This and the next subsection are very concise. I would suggest more information be provided: Which minimization function was used to find the minimum between measured and calculated temperatures? How does the sensitivity matrix help to reduce the misfit or minimize the cost function? Why the QR scheme was chosen?

Subsection 3.2.2 PSO reconstruction. Change to PSO method. The same here. I

TCD

6, C1401–C1404, 2012

would like to see more explanation of this method, especially the minimization function which was used to find the minimum between measured and calculated temperatures and so on.

3.3. Numerical convergence

Usually the choice of the initial condition is important for inverse type problems. Depending on different initial temperature distribution the reconstructed surface temperatures might be different. It would be interesting to see the sensitivity analysis of the initial condition as well.

P2581. L13 It would be reasonable to explain the rationale behind the authors' choice of these three assumptions. Why these assumptions were chosen? Why is it important to test them?

P2581. L24-28. It is not clear why the increase of grid spatial resolution should affect recovered at the ground surface temperatures.

4 Surface temperature reconstruction

P2582. L13 It would be helpful to show a formula for RMS error. Usually there are minimization methods employed to find the optimal solution that corresponds to the minimum of RMS.

P2582. L26 Elaboration is needed on how the minimization was done and which minimization method was used for LSQR method.

P2583. The measured temperature distribution on Fig. 4 is not shown.

5 Discussion.

Fresh, recently fallen snow usually has a very low thermal conductivity and can alter the ground surface heat budget as well.

Interactive comment on The Cryosphere Discuss., 6, 2575, 2012.