

Interactive comment on “Impact of the Last Glacial Cycle on Late-Holocene temperature and energy reconstructions from terrestrial borehole temperatures in North America” by H. Beltrami et al.

Anonymous Referee #1

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General appreciation

In this paper, the authors assess the magnitude of thermal energy contributions from the Last Glacial period to the subsurface for regions that were characterized by significant ice coverage during that period. In the assessment, they couple the output from an ensemble ice sheet model to a subsurface temperature model. The basal temperatures from the ensemble model are used as a Dirichlet condition to the latter model. The authors find that subsurface disturbances to the semi-equilibrium geothermal gradient are relatively small at depths between the surface and 600m. However, in

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terms of quantity of heat differences between taking into account ice sheet variations on the Last Glacial period or not may differ up to 50%, which is of course a much more important factor to take into account.

The paper is well written, to the point and covers an interesting subject worth publishing in Climate of the Past. I only have a couple of minor comments to improve the manuscript. One of these is that I wonder why the boundary condition to the thermal subsurface model is taken as a Dirichlet boundary condition (basal temperatures), and not the basal temperature gradients stemming from the ice sheet model ensemble. Wouldn't the latter ensure continuity between both models? It would probably also be more consistent in its approach. The ice sheet model uses a Neumann condition at its base, based on a (supposed) value of the geothermal heat flow and extended with heat generated through basal sliding and it seems therefore logic that using the ice sheet model basal temperature structure as a perturbation to the subsurface thermal model continues from this condition. This aspect should be argued in the text/discussion.

Another comment is that basal processes underneath (paleo) ice sheets are crucial in the determination of basal temperatures. These are especially regions of fast flow, sediment covered areas (hence saturated sediment deformation), subglacial lakes and basal hydrology (channels, cavities). These processes significantly alter the basal heat budget. How good are the ensemble model results with respect to these processes? How is basal hydrology represented in the ice sheet model? Were there large subglacial lakes underneath the Laurentide ice sheet (later on becoming proglacial lakes) influencing the heat budget and how are they taking into account?

Detailed remarks

P 2360: If the temperature profile is represented by a linear function, it should be added what the physical meaning is: this is the steady state temperature profile for vertical diffusion process only in which the slope depends on the basal heat gradient (geothermal heat, other processes?).

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P 2361: development and demise? Aren't there any simpler terms, such as buildup and melt, or waxing and waning. Demise is often used in a different context (more related to humans than to things).

P 2362, L 6: is it "expand on the theoretical basis of BTP modeling and interpretation that are relevant to" or "... is relevant to" (depending what is meant. Not very clear phrasing).

P 2362: What is the permafrost resolving thermal model as part of the ice sheet model? How does this model cope with the temperature evolution in the subsurface? In what does it differ from the analytical subsurface model that is used later on? Are basal temperatures the only measure that is important for the subsurface model? Why are basal temperature gradients from the ice sheet model not used as a (Neumann) boundary condition? They seem to be available. See also P 2364

P 2363 L 18: calving is also part of ice dynamics. Why putting this term separate? You may then also mention basal sliding as a relevant process that influences (probably more) the basal conditions of the ice sheet.Ã

P 2364: Diffusivity of rock is given. Is it only rock that matters? Are sediment layers not of importance (I can imagine that the heat budget of those, especially enriched with water) could be important.

P 2367: Remove section 3 header. Make the two sub-sections separate sections.

P 2374: top: something is missing here. Should be "since/from/at? 100 ka"

Interactive comment on Clim. Past Discuss., 10, 2355, 2014.