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New borehole-derived results on temperatures at the base of the Fennoscandian ice sheet

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During the last few years, a data base of deep boreholes (>1000 m)in the area of the Fennoscandian ice sheet has been collected, including boreholes from Russia, Poland, Finland, Sweden and Norway. All of these are supposed to have recorded local basal ice conditions during the last glacial cycle. However, at each of these sites we are confronted with particular problems of interpretation. Here, we will concentrate on two very deep boreholes, namely the Outokumpu ICDP borehole (OKU, $\approx$2500 m) and a set of boreholes of intermediate depth (up to 1300 m) in the immediate meighborhood of the Kola superdeep borehole SG3.

In the first case, OKU, we have developed a strategy combining the use of a traditional variational inversion of thye Tikhonov type, with a MCMC approach for the exploration of the associated uncertainty. A wide distribution around the result of the variational approach was chosen, with a time dependent temporal correlation length reflecting the loss of resolution back in time. The results fit very well with region independent results from different proxies, multi-proxy reconstructions, and instrumental data. They also are consistent with surface temperatures derived from recent calibrated ice sheet models. The SAT-GST offset independently derived from shallow borehole observations in the area was a crucial step to obtain theses results.

The second case, SG3, has been studied a long time, and no final result was obtained regarding the question whether the observed heat flow density profile is caused by paleoclimate, fluid flow, or both. Earlier studies, as well as forward modelling using the results of the aforementioned ice sheet model indicate that paleoclimate alone can not explain the observations. We tested the model derived from the set of shallow boreholes against the temperature log from the main superdeep SG3, which, in contrast to these, transects the main high-permeability zone. The comparison led to a favorable results, and is also qualitatively consistent with other data reported in earlier Russian publications.

However, for the SG3 case, which involves fluid flow processes, there are still important open questions. These are related to some of the assumptions made in the modeling and inversion process. The temperature conditions at the base of the ice sheet are surely not it's only effect: the high pressures induced but the ice load are known to drive melt water deep into the subsurface, with unknown temperature effects. Moreover, the crustal deformation related to isostatic effects probably influence large-scale permeability, in particular if older structures can be reactivated. These questions will be discussed in the light or recent modelling results obtained by groups active in nuclear waste disposal research, and which may open new research perspectives in the future.