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Effects of long-term history on borehole paleoclimatology

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Temperature changes at the surface of the earth propagate downward into the earth and are stored as perturbations to the subsurface equilibrium thermal regime associated with heat flow from the interior of the earth. Within the context of Borehole climatology, a methodology that has been widely used to reconstruct past ground surface temperature histories (GSTH), we examine the effect on the reconstructed GSTH arising from the changes that took place up to 120 kyrs before the present. The changes include the presence of an extended ice sheet, the duration of this cover, and the basal conditions of the ice sheet to account for the climatological interpretation of borehole temperature profiles.

We choose three different sites from Canada. For each site, we have extracted 120 kyrs to present ground surface temperature time-series for a range of ice-cover histories from a data-calibrated glacial systems model for the last North American ice complex. These time-series provide a transient upper boundary condition for a 1-D subsurface heat transport model. This forcing introduces a thermal anomaly on a synthetic steady-state geothermal regime with equilibrium surface temperature of 8.0 C and geothermal gradient of 20 K km^{-1} under the assumption of an homogeneous subsurface.

The corresponding results are sampled for depths of 600 m and 1000 m and are used to reconstruct the climate-induced subsurface anomalies. These anomaly profiles indicate that the long-term history has an effect that is visible at both depths but the effect is prominent at larger depths. For each site, we also use a series of 1000 Monte-Carlo experiments where Gaussian noise with zero mean and standard deviation of ± 0.5 K is added to the forcing time series in order to give an estimate of the range of variability of the subsurface anomalies.