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Borehole temperature response for competing models of Laurentide ice sheet dynamics

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Borehole temperature profiles (BTP) are not only the source for estimates of the background geothermal heat flow, but also allow the reconstruction of past surface temperature changes. Though shallow boreholes (e. g. less than 500 m) are abundant in most continental areas, their use is inhibited by the necessity of extracting the paleoclimatic signal present in the borehole temperature at any depth. However, assuming a long-term ground surface temperature history (GSTH), a generalized reduced temperature may be used for the interpretation of the shallow observations. To derive or test the required assumptions, very deep boreholes (say, > 2000 m) are highly important also for the investigation of shallow measurements.

In areas which were influenced by the Last Glacial Period (LGP), the existence of the large scale ice sheets (e.g. the Laurentide or Weichselian), the spatial distribution of basal conditions, and the timing of their retreat have a major influence on the subsurface temperature regime. Though for parts of its history no longer directly related to atmospheric temperature, deep BTPs carry information on basal conditions, oceanic transgressions, and retreat histories, and can thus contribute to the confirmation/rejection, or even calibration of ice sheet models. From this it follows that a meaningful interpretation of the paleoclimatic signal can only proceed with a reasonable understanding of the regional ice sheet behavior, and, in order to quantify the effects, a calibrated numerical ice sheet model. From such a model, synthetic long term GSTHs may be generated, which can subsequently be used to derive the generalized reduced temperatures for the shallow BTPs. This approach is challenging in several aspects: (1) high-resolution, high-order/hybrid ice sheet models are only now emerging, and the physics at the base (e.g. ice streams) needs improvement; (2) a calibration in the sense of a Bayesian inverse problem are rare, and (3) appropriate sets of borehole data (including the corresponding metadata) still have to be collected and need to undergo strict quality control before being used. In addition, a methodological concept fora regional interpretation is missing.

In this contribution we will compare the borehole temperature response for two ice sheet models of the Laurentide glaciation, differing in their dynamics. Both were realized by running the hybrid SIA/SSA code GRISLI in different modes. The subsurface temperature anomalies thus generated are significant. Unfortunately the existing deep boreholes in the area are not placed in areas of high sensitivity (e.g., Northern Quebec, Canadian Archipelago). Notwithstanding these difficulties, we will present results for some of these available boreholes in central and northern Canada and Alaska.