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Geothermal effects on subglacial lakes beneath the last Cordilleran ice sheet

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The Cordilleran ice sheet, which covered the mountain ranges of north-western America during the last glacial cycle, provides an ideal setting to study the effect of geothermal anomalies on subglacial water routing and ponding beneath large-scale ice masses. First, the Cordilleran ice sheet rested directly on a geologically old yet still active subduction zone, which is responsible for significant geothermal variability in the region. Second, the deep valleys and intramontane basins that characterize the Cordilleran topography tend to act as flux wells to further enhance the heterogeneity of this geothermal distribution. Third, compared to the currently ice covered areas such as Greenland and Antarctica where direct observations of the geothermal distribution are exceedingly rare, the region of the North American Cordillera offers insights into geothermal variability from numerous borehole measurements taken across western territories of the US and Canada. Fourth and last, the subglacial water system left ample evidence on the landscape, including vast esker systems, deep canyons and tunnel valleys, allowing for an interpretation of the modelled hydrological networks and their comparison with geological data.

Here we combine the Parallel Ice Sheet Model (PISM) to a subglacial lake ponding algorithm to simulate ice dynamics and simplified subglacial hydrology of the Cordilleran ice sheet through the last 120 000 years. We test several existing reconstructions of the geothermal flux from direct observations and proxies versus a uniform distribution of heat flux to isolate the effects of regional geothermal variability on thermo-hydrological conditions and subglacial lake formation at the base of the last Cordilleran ice sheet. We find that the uncertainties in the geothermal flux distribution as well as regional geothermal anomalies present in the reconstructions have little effect on the modelled ice extent and thickness, but they affect the distribution of melt rate, water routes and subglacial lakes beneath the ice sheet. Some of the reconstructions used result in increased water content in the Fraser and Okanagan Valley system due to high geothermal heat flux in upstream zones, showing the role of these regional anomalies on the formation of subglacial lakes previously documented by geomorphology in this region.