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Geothermal activity at Bárdarbunga, Iceland, following the 2014–15 caldera collapse, investigated using numerical modelling of shallow geothermal activity

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The gradual collapse of the subglacial Bárdarbunga caldera in 2014–2015 provided an opportunity to explore the geothermal signals produced by large-scale subsidence. A few weeks after the start of the collapse, ice cauldrons began to form on the caldera rims, due to melting at the base of the glacier, with several more cauldrons forming in the following years. The shortest-lived cauldron on the caldera rim was active for 7 months, and others continue to increase in volume after several years. The ice acts as a calorimeter, and the ice cauldron volumes are used to estimate the heat flux at the glacier base. Numerical simulations of fluid flow and heat transport in the uppermost 1 km of the crust were performed using HYDROTHERM, to assess the possible role of shallow magmatic intrusions in generating the ice cauldrons. A range of likely permeability values and initial bedrock and groundwater temperatures were explored. The heat transfer required to create the more rapidly formed non-eruption cauldrons at the caldera rims can be reproduced with shallow intrusions and high permeability pathways, which were found to greatly enhance the surface thermal signal. The delay in onset time for some of the cauldrons suggests, however, that such pathways are not always present. The pre-intrusion temperature of the surrounding bedrock has a major effect on heat transfer to the surface, with cold bedrock causing a buffering effect, whereas temperature conditions close to the boiling point of water produce far more efficient heat transfer due to the formation of steam plumes. Not all behavior observed is reproduced in our models, suggesting that changes to geothermal reservoirs below 1 km depth may play a significant role in the observed thermal anomalies.