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Distributed fibre-optic temperature sensing in a 1 km borehole drilled on a fast-flowing glacier in Greenland

Robert Law[1], Poul Christoffersen[1], Bryn Hubbard[2], Samuel Doyle[2], Thomas Chudley[1], Marion Bougamont[1], and Charlie Schoonman[1]

[1]University of Cambridge, Scott Polar Research Institute, Cambridge, United Kingdom

[2]Aberystwyth University, Centre for Glaciology, Aberystwyth, United Kingdom

Whilst marine-terminating glaciers in Greenland are significant contributors to global sea level rise, their thermodynamics are poorly constrained by observations. Conventional discrete thermistor borehole sensing studies go some way to addressing this but lack the spatial resolution to effectively resolve key processes. Here, we detail results from fibre optic distributed temperature sensing equipment installed in a 1040 m hot water drilled borehole 28 km inland of the calving front of Store Glacier, Greenland. Surface ice velocity at the borehole is 550 m a^{-1} with convergent ice flow into a bedrock trough. Spatial resolution of 0.25 m, temperature differences of 0.03 °C, and an absolute temperature accuracy of 0.15 °C were achieved. 0.5 °C warm anomalies were observed between 0-30 and 220-45 m depth with a central cold section down to -22 °C . We interpret the former anomaly to be a result of cryo-hydrologic warming, although of lower magnitude than in slow-flowing sectors of the Greenland Ice Sheet. The latter is theorised to be strain heating, supported by deformation observed in the cable at this point. The record also reveals a 75 m thick section of temperate basal ice and the nature of the cold-temperate transition as a sharp temperature drop of 0.45 °C over 1.5 m at the top of the temperate layer, with notable temperature changes in the vicinity of the transition. Warming of 0.06 °C is observed over the basal 6 m of the profile. The cable lasted 6 weeks before failure, demonstrating the feasibility of using fibre optic sensing to study thermal processes in a glacier environment with high deformation rates.