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Numerical modeling of the temperature and flow field of McCall Glacier, Alaska, constrained by borehole temperature data

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During IPY, an extensive field programme was set up on McCall Glacier, Alaska including borehole drilling to the bed at three locations. These holes were instrumented with a continuously-logging thermistor strings. Despite the low mean annual air temperatures (-10°C), temperate ice throughout the borehole in the accumulation area was observed, explained by the latent heat release due to refreezing of surface melt water in the firn. A 200m deep hole drilled in a cirque further down-glacier (2123m) shows that it is actually cooling substantially: the site has switched from accumulation to ablation area, ablating the firn away completely. This allows cold air temperatures to penetrate deeper in the ice, gradually cooling the upper part of the glacier. A third hole in the ablation area (1717m) is the coldest of all, though temperate at the bed because of large frictional heating rates due to basal sliding.

Using a 3D higher-order thermodynamical model we simulated the time-dependent increase in equilibrium line altitude and associated reduction of the accumulation area. The temperature profiles were used as constraints to control the change from warm to cold conditions in the upper part of the glacier. Further constraints stem from accumulation/ablation measurements as well as repeat surface velocity measurements along the central flowline of the glacier. Results of these experiments show that the cooling trend in the lower cirque is going on for at least 40 years, which is corroborated by previous mass balance reconstructions of the glacier.