Supporting information for "Radar sounding survey over Devon Ice Cap indicates the potential for a diverse hypersaline subglacial hydrological environment"

Anja Rutishauser[1*], Donald D. Blankenship[1,2], Duncan A. Young[1], Natalie S. Wolfenbarger[1], Lucas H. Beem[2], Mark L. Skidmore[2], Ashley Dubnick[3], and Alison S. Criscitiello[3]

[1]Institute for Geophysics, University of Texas at Austin, Austin, TX 78758, USA
[2]Department of Earth Sciences, Montana State University, Bozeman, MT 59717, USA
[3]Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta, Canada

1 Definition of new lakeshores over T2

New lake shores are derived from a combination of elevated basal reflectivity and hydraulic flatness in a two-step process: First, preliminary lake shores over bedrock trough T2 are defined on a grid cell by grid cell basis (using the 500 m hydraulic head mesh), where a grid cell is defined as part of a subglacial water body if the cell has a hydraulic slope ≤ 0.7º, corresponding to the mean slope over the T2 trough region, and has a mean reflectivity R anomaly ≥ 8.1 dB, corresponding to one-standard deviation from the mean of all observed reflectivities beneath DIC (Fig. S1). The R ≥ 8.1 dB criteria here is reduced compared to one used for the identification of subglacial water from individual data points (R ≥ 12 dB) as the reflectivities here are averaged over the grid cells and possibly include lake-margin areas. Neighboring grid cells that are not hydraulically flat, but pass the reflectivity threshold R ≥ 8.1 dB are included, allowing the inclusion of areas with shallow water near the lake shores where a hydrostatic equilibrium may not be fully developed. In contrast, stand-alone grid cells where the above thresholds apply are neglected. Finally, the shorelines are manually refined based on visual inspection of basal reflectivities along the radar transects. This allows for a more precise identification of the shorelines compared to the algorithm, which averages reflectivity values over the grid cells (Fig. S1). As such, the grid cells clustered in the eastern part of the trough (~440 km Easing) that pass the above defined thresholds for the hydraulic flatness and reflectivity are excluded from our lakeshore definitions due to generally lower along-track reflectivity (R ≤ 12 dB).

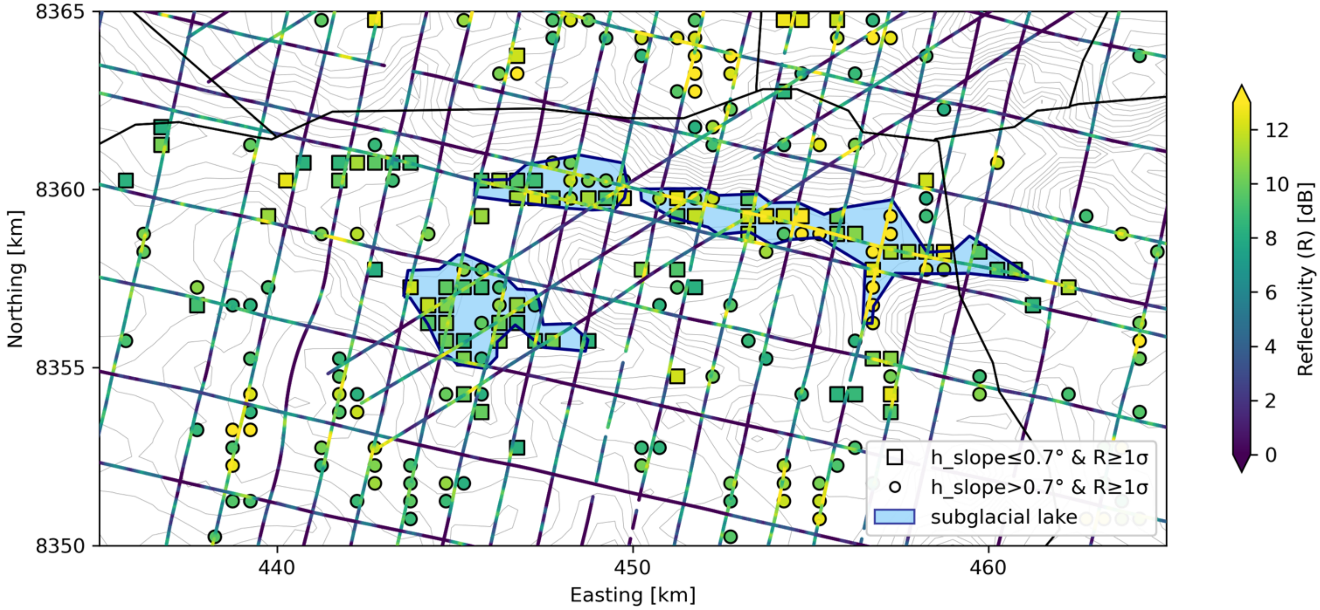

Figure S1. Illustration of criteria used for the definition of the new shorelines of the subglacial lakes in bedrock trough T2. The radar survey lines are color coded with the smoothed along-track basal reflectivity normalized around the mean. The same color code is applied to the squares and circles, which represent the mean reflectivity within a grid cell of the hydraulic head. Squares represent grid cells which pass both the reflectivity and hydraulic flatness criteria for a subglacial lake while circles only pass the reflectivity criteria. These areas are only included when neighboring grid cells pass both criteria (squares), and potentially indicate areas of bridging stresses or shallow water/saturated sediments near the lake shorelines. Thin black lines represent the bedrock topography (25 m interval) whereas thick black lines mark the location of the ice divides.

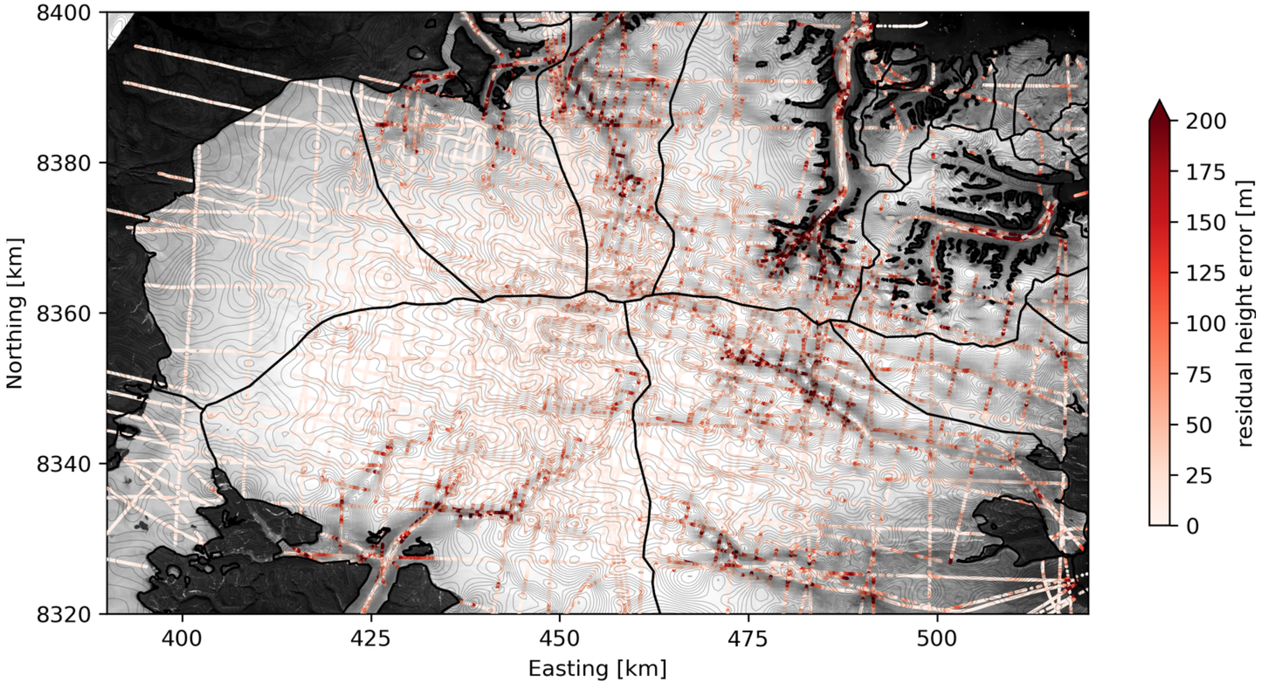

Figure S2. Absolute difference between the bedrock DEM and bed elevation data points along the radar transects. Thin black lines represent the 25m bed DEM contour lines.

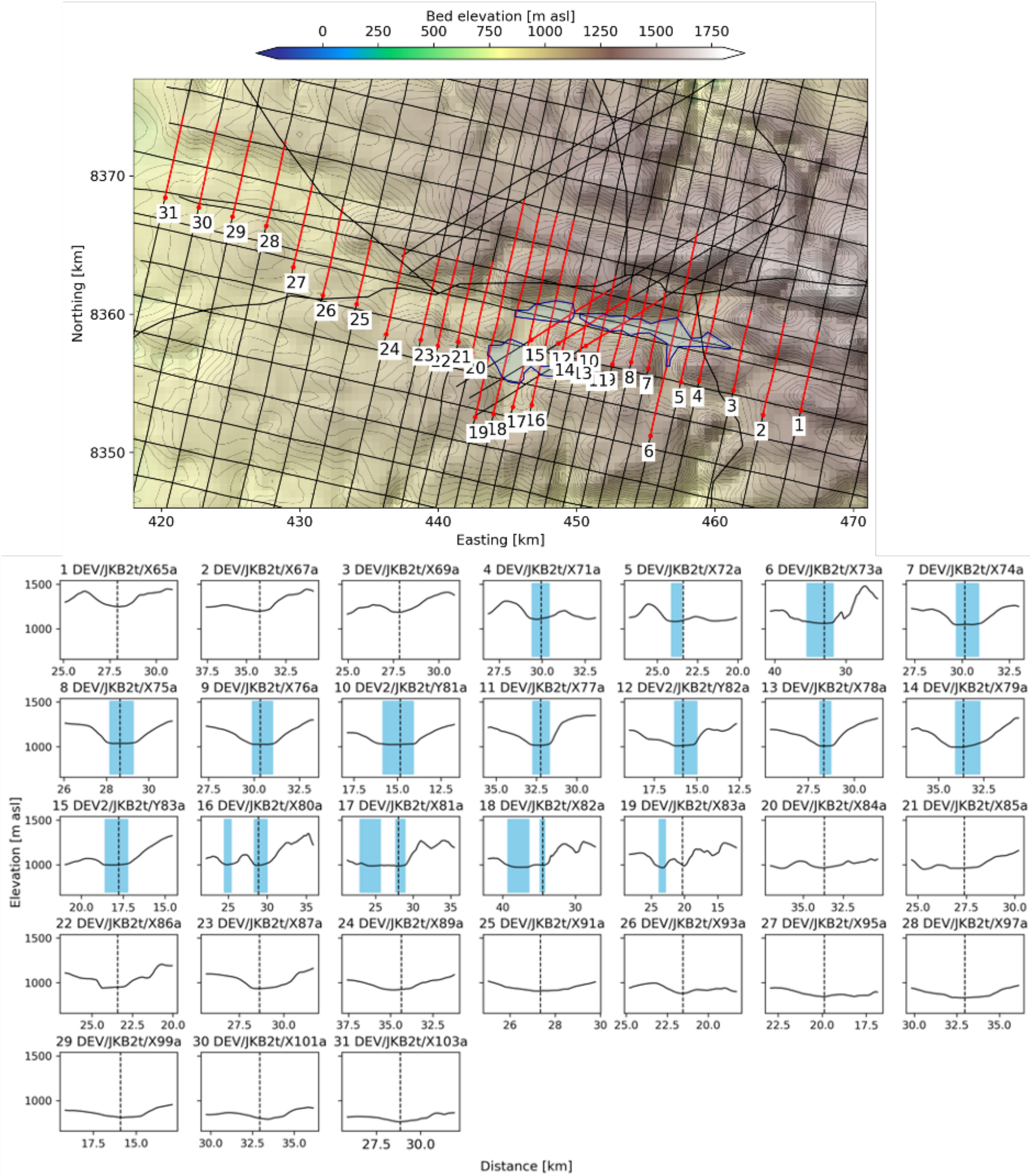

Figure S3. Bedrock elevation along radar profiles over bedrock trough T2 and its canyon extension. Areas over the subglacial lakes are shaded with blue. Vertical dashed lines represent the approximate trough center. Profiles named DEV2 (10, 12, 15) are the profiles flown at a 45º angle over T2.

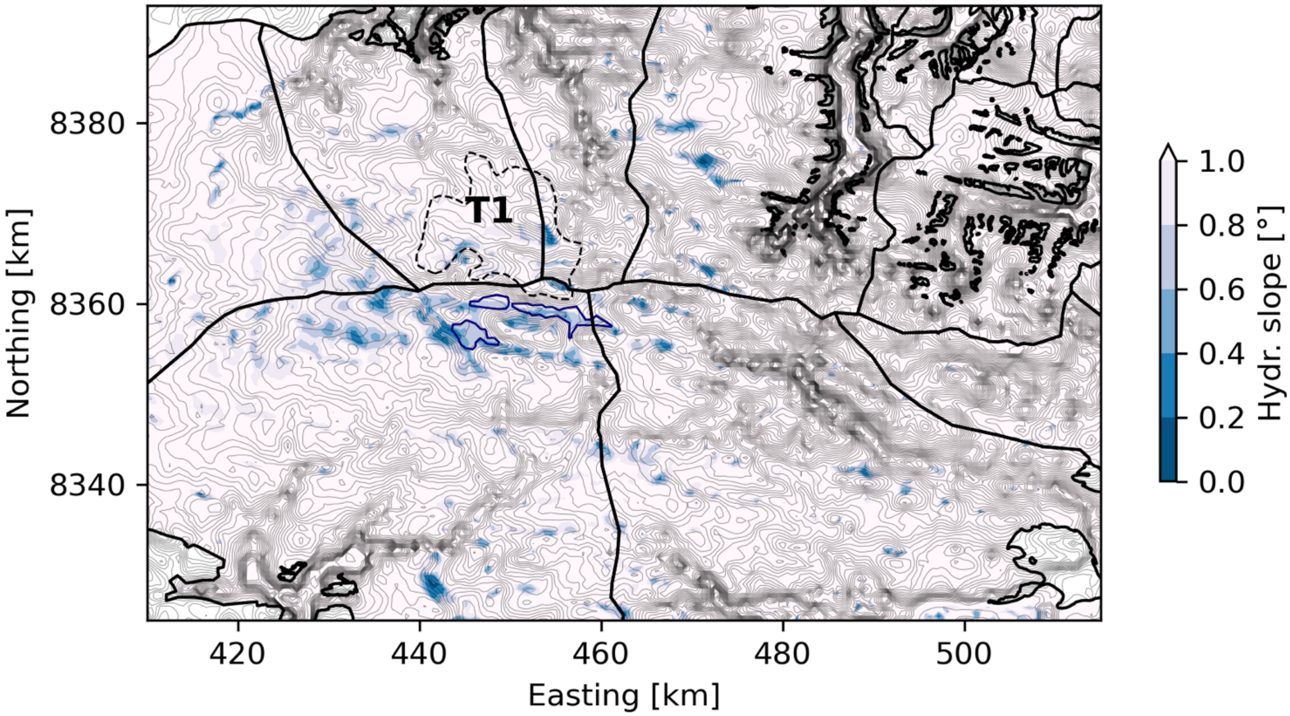

Figure S4: Map showing areas with hydraulic slopes < 1º. Thin black lines represent the bedrock topography (25 m interval) whereas thick black lines mark the location of the ice divides. Outlines of the subglacial lakes A-C are marked in blue, and the brine network surrounding the T1 area is marked with the black dashed line.

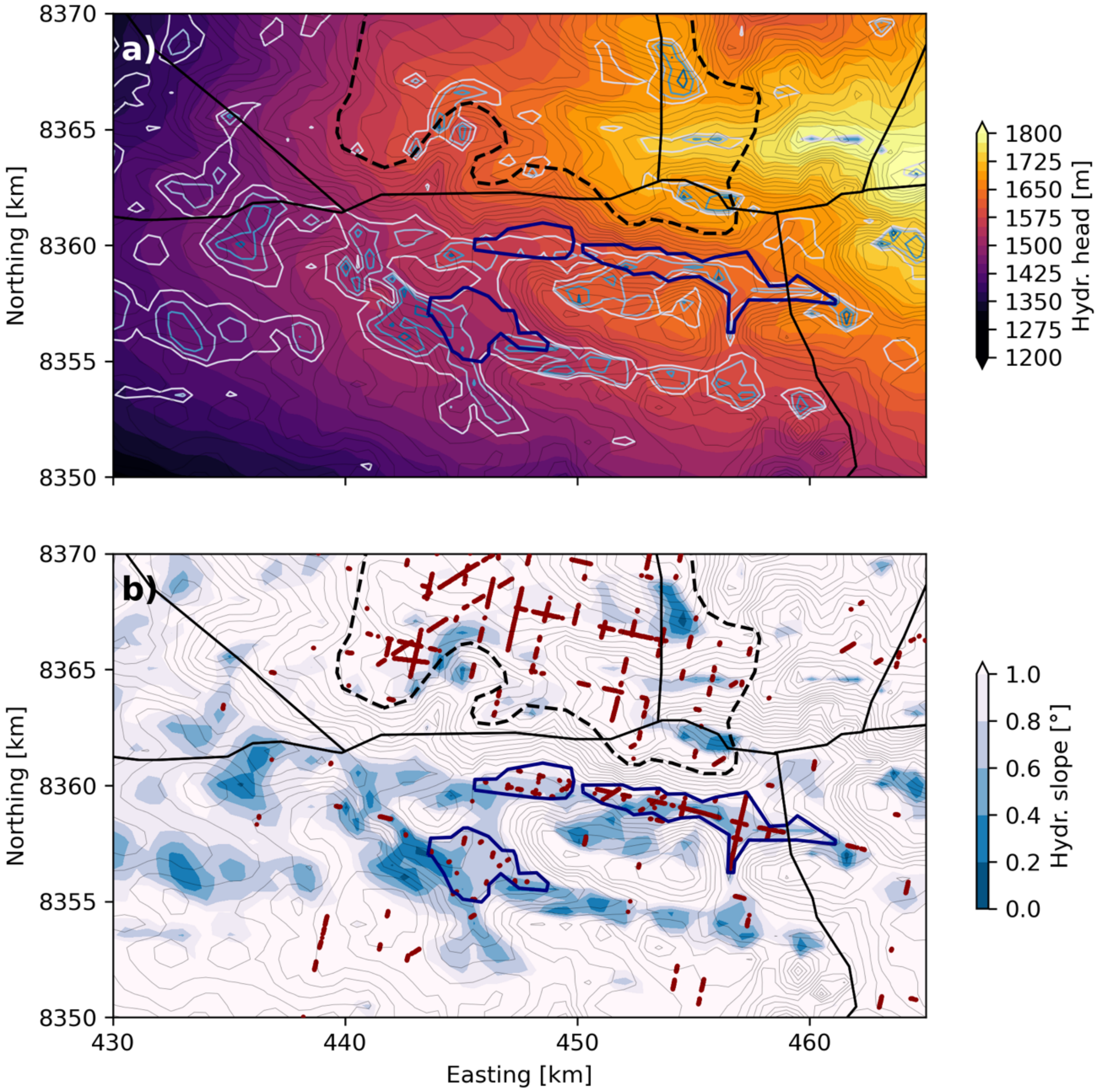

Figure S5. Hydraulic head (a) and slope (b) in the area of the subglacial lakes A-C (blue outlines). Contours in a) correspond to the hydraulic slope marked on b). Red dots represent reflectivity anomalies larger than 12 dB, and black dotted line marks the outline of the interpreted subglacial brine network.

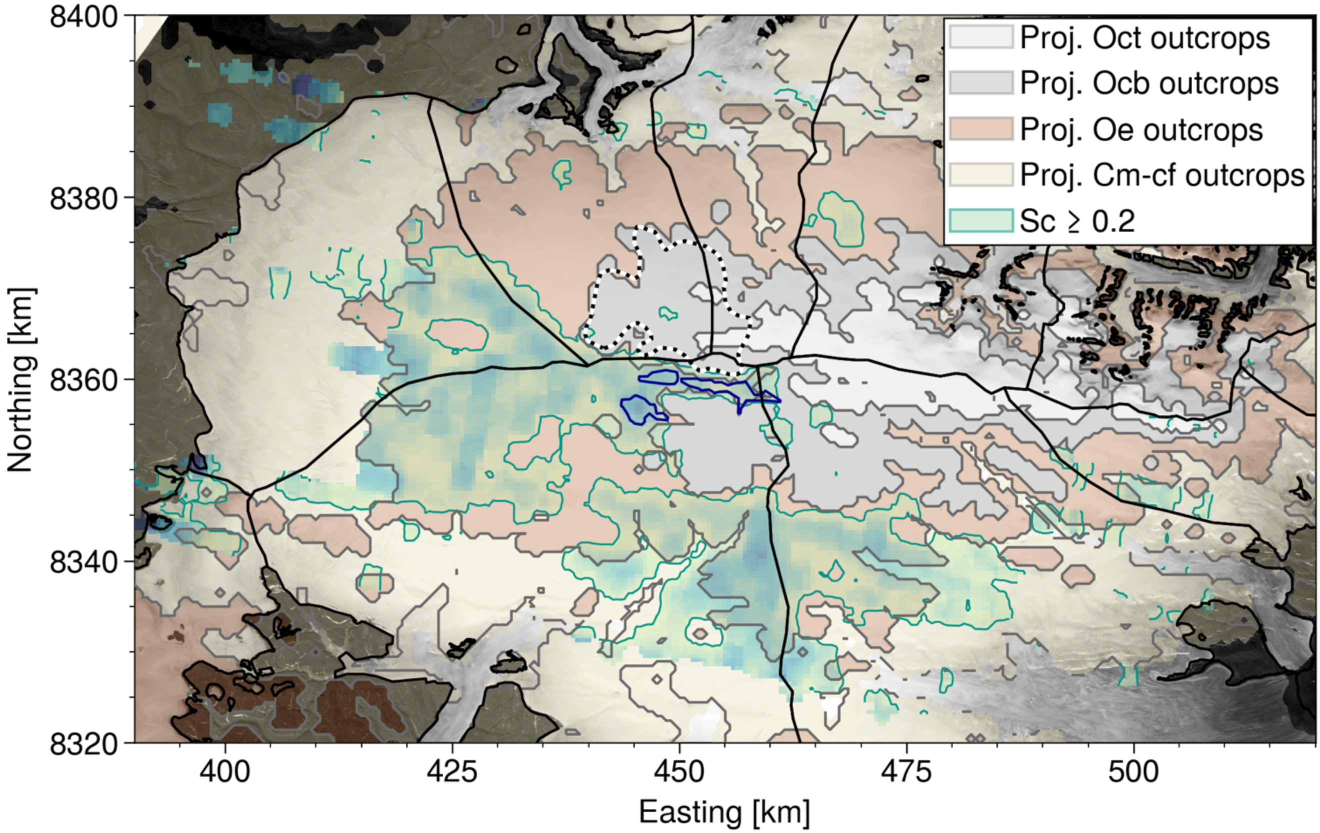

Figure S6. Landsat image overlain with the projected outcrops of different geological units, areas of high specularity content Sc and the locations of the subglacial lakes (blue) and brine network (black-white dotted line). The geological units were projected using the geology model from Rutishauser et al. (2018) and the updated bed topography DEM from this study. Details on the geological units can be found in Harrison et al. (2016), Mayr (1980) and Thorsteinsson and Mayr (1987)**.**

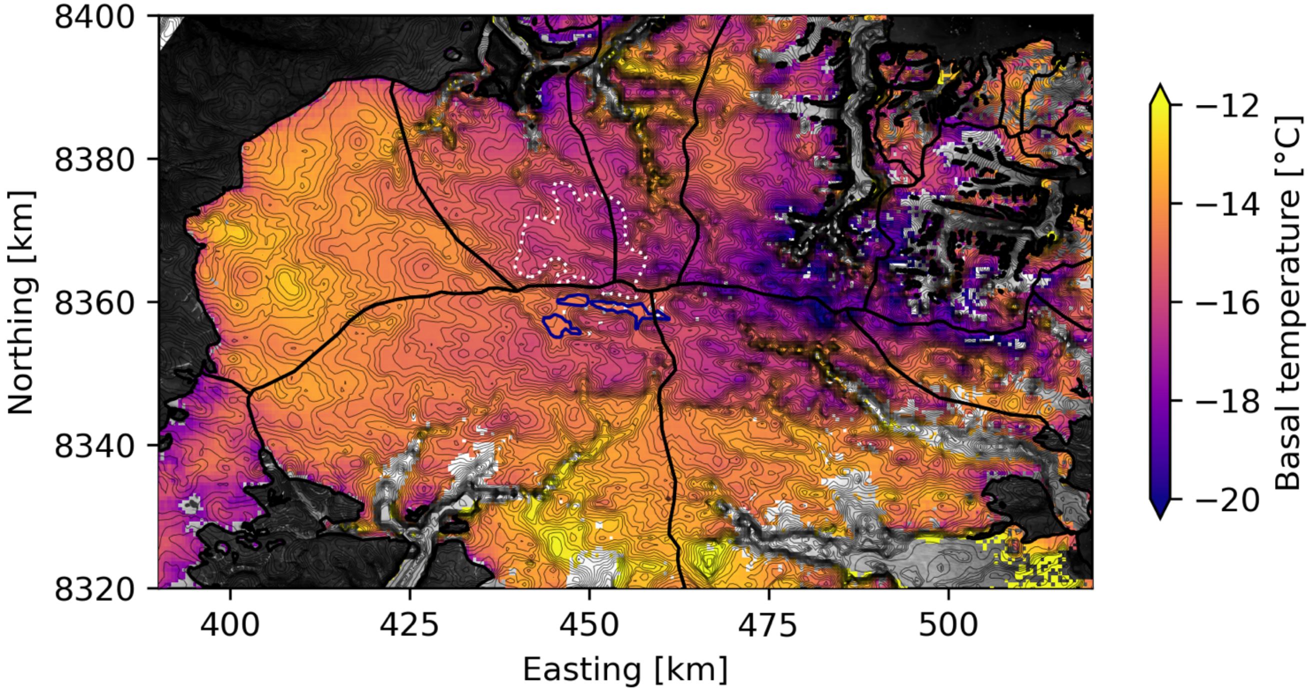

Figure S7. Basal ice temperature. Derived where the ice velocity is below 20 m/yr, using the same model and parameters as described in Rutishauser et al. (2018). Outlines of the subglacial lakes A-C (blue) and the brine network (white dotted) are marked.

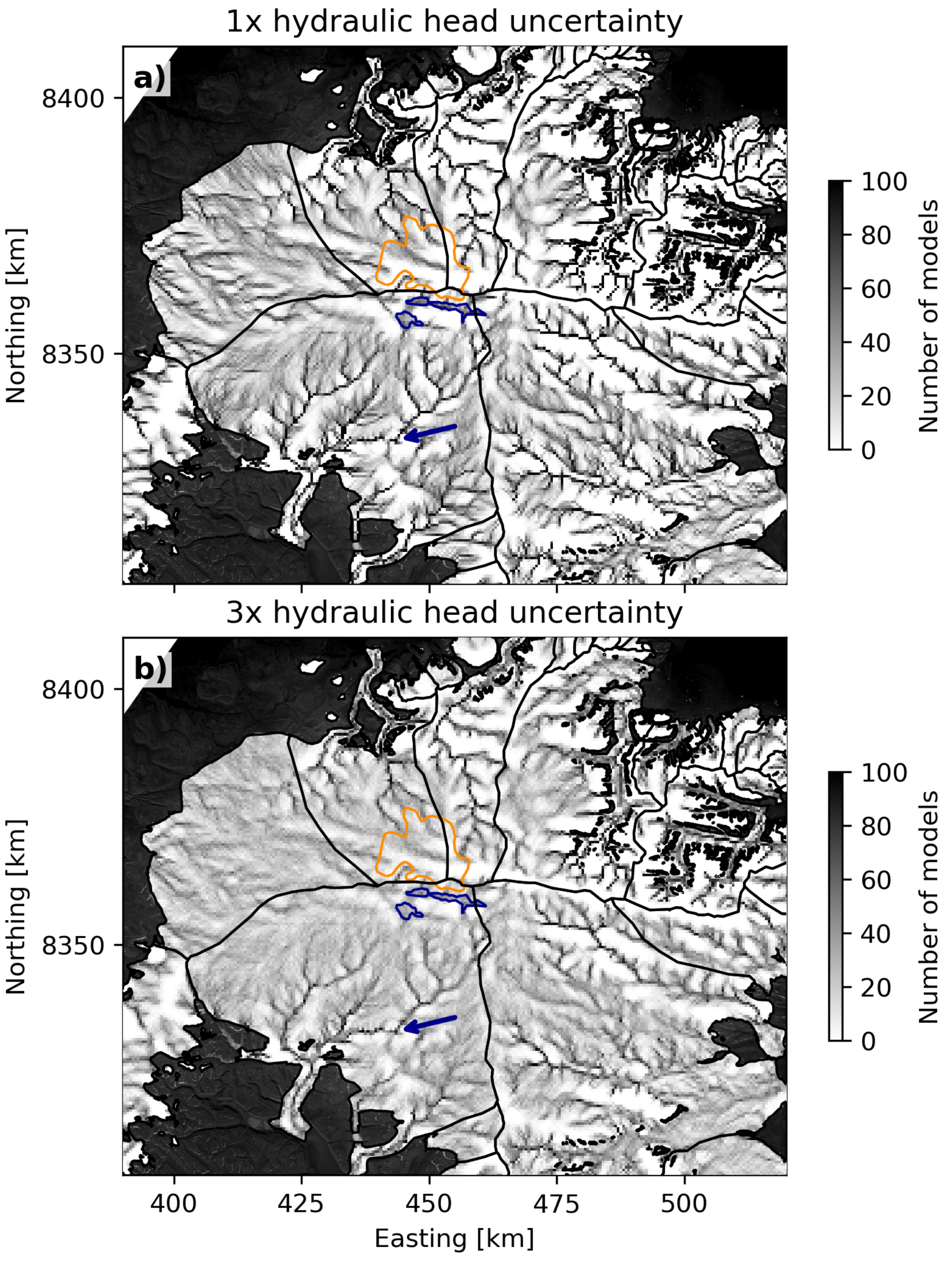

Figure S8. Modeled potential subglacial hydrological pathways beneath DIC, using one (a) and three (b) times the uncertainty of the hydraulic head as randomly distributed errors. Outlines of the subglacial lakes and brine network are marked in blue and orange, respectively. Arrow marks the location where this comparison reveals the uncertainty of water flow from the subglacial lakes onto North Croker Bay Glacier or South Croker Bay Glacier.

References

Harrison, J. C., Lynds, T., Ford, A. and Rainbird, R. H.: Geology, simplified tectonic assemblage map of the Canadian Arctic Islands, Northwest Territories - Nunavut, Geol. Surv. Canada, Can. Geosci., Map 80, doi:10.4095/297416, 2016.

Mayr, U.: Stratigraphy and correlation of lower Paleozoic formations, subsurface of Bathurst Island and adjacent smaller islands, Canadian Arctic Archipelago, Geol. Surv. Canada, Bull., 306 [online] Available from: https://doi.org/10.4095/102157, 1980.

Rutishauser, A., Blankenship, D. D., Sharp, M., Skidmore, M. L., Greenbaum, J. S., Grima, C., Schroeder, D. M., Dowdeswell, J. A. and Young, D. A.: Discovery of a hypersaline subglacial lake complex beneath Devon Ice Cap, Canadian Arctic, Sci. Adv., 4(4), eaar4353, doi:10.1126/sciadv.aar4353, 2018.

Thorsteinsson, R. and Mayr, U.: The sedimentary rocks of Devon island, canadian arctic archipelago., 1987.