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Relating polarimetric radar measurements of ice fabric to ice-flow enhancement of Rutford Ice Stream

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Lateral shear margins provide resistance to ice flow within ice streams and play an important role in the overall dynamics of ice sheets. The strength and location of shear margins are known to be influenced by both subglacial factors (e.g. bed roughness, meltwater availability) and ice rheology (ice temperature, ice fabric, and damage). Assessing the relative contribution of these factors upon ice-stream flow is complex but can be aided by geophysical measurements (e.g. radar-sounding and seismic imaging) of the ice-stream subsurface. There are, however, ongoing challenges in obtaining geophysical information in an appropriate form to be incorporated into ice-flow models. This is true of ice fabric, and its direction-dependent effect upon ice viscosity is typically neglected in models of ice streams.

Here we develop a framework to relate ice fabric measurements from polarimetric radar sounding to ice-flow enhancement within ice streams. First, we extend a `polarimetric coherence' radar method to automate the extraction of ice fabric using quad-polarized data. Second, using a previously developed anisotropic flow-law formulation, we relate the radar fabric measurements to direction-dependent enhancement factors of glacier ice. We demonstrate the approach using a radar ground survey, collected by the British Antarctic Survey, which traverses between the centre and shear margin of Rutford Ice Stream. The data indicate that a vertical girdle fabric is present in the near-surface of the ice stream (approximately the top 300 m) which azimuthally rotates and strengthens toward the shear margin. We then assess the effect that the girdle fabric has upon shear and compression and the impact upon ice-flow models of Rutford Ice Stream.