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Ice fabric in an Antarctic ice stream interpreted from seismic anisotropy

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It has long been known that glacial ice is anisotropic. Crystal alignment during ice compaction and flow forms ice fabrics which significantly affect the mechanical properties of the ice. However, numerical models used to predict the evolution of ice flow in key regions such as Greenland and Antarctica do not effectively take anisotropy into account, due to a lack of in-situ estimates of ice fabric to drive them. This is a particular problem in fast-flowing ice regions, such as ice streams, where it is challenging to obtain ice samples.

Here we present new measurements of a clear anisotropic ice fabric in a fast moving (377 ma^{-1}) ice stream in West Antarctica. We use ∼6000 measurements of shear wave splitting observed in microseismic signals from the bed of Rutford Ice Stream, to show that the ice in this area is dominated by a previously unobserved type of partial girdle fabric. This fabric has a strong directional contrast in mechanical properties, shearing 9.1 times more easily along the ice flow direction than across flow. This observation is likely to be widespread and representative of other ice streams and large glaciers. Ice streams are the key outlet pathways for ice sheets and therefore an understanding of how best to model ice flow in these regions is essential to accurately predict the future stability of the cryosphere. This study is the first conclusive study of which we are aware that provides a robust model of ice stream fabric using shear wave splitting in microseismic data, providing key results for data-driven ice flow modelling.