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Fabric beats in radar data across the NEGIS ice stream

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Crystal anisotropy of ice causes slight birefringence for electromagnetic waves. At the same time, the mechanical anisotropy amounts to several orders of magnitude, thus making fabric properties highly-relevant for internal deformation. To date, bulk anisotropy of glaciers and ice sheets can be determined by geophysical methods, such as polarimetric radar, or direct sampling from ice cores. A shortcoming has been so far that changes of bulk anisotropy could mainly be inferred at single point observations, but less so as continuous profiles. Here, we exploit the effect of birefringence caused by bulk anisotropy in co-polarized airborne radar data to determine the horizontal anisotropy across the North-East Greenland Ice Stream. We base our analysis on the fact that birefringence causes a second-order effect on radar amplitudes, which leads to a beat frequency in the low and medium frequency range (O(100 kHz)), which is proportional to the horizontal anisotropy. Complementing our radar analysis with direct fabric and dielectric property observations we can constrain the range of all three fabric eigenvalues as a function of space across and along the ice stream. Finally, we assess the effect of the inferred fabric distribution on the overall ice rheology in the context of ice stream dynamics. Our overall approach has the advantage that it can be applied to co-polarized radar systems, as commonly used in profiling surveys, and does not require dedicated cross-polarized radar set-up. This provides the opportunity to revisit older data, especially from Greenland and Antarctica, to map fabric anisotropy in ice-dynamically interesting regions.