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Layer-Optimized Synthetic Aperture Radar Processing for Slope Detection and Estimation

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Englacial layers in Antarctica and Greenland are indicators of the dynamic, rheological, and subglacial configuration of the ice sheets. Airborne radar sounder data is currently the primary remote sensing solution for directly observing englacial layers and imaging englacial structures at the glacier-catchment to ice-sheet scale. Traditional along-track synthetic aperture (SAR) processing can limit the detectability and interpretability of englacial layer geometry due to destructive interference in the processed signal. This reflection loss can destroy layer signals and obfuscate automatic or manual tracing and interpretation.

To address this challenge, we provide a reconstruction algorithm to address the problem of destructive phase interference during the radargram formation. We develop and apply a novel SAR processor optimized for layer detection that enhances the Signal-to-Noise ratio of specular reflectors of any steepness. The algorithm also enables the automatic estimation of layer slope. Notably, this approach does not require layers to be long or continuous to produce usable slope fields, overcoming limitations of previous approaches developed for shallower and slower-flowing areas with intact layers.

We illustrate the application of this new processing approach to create 2D slope fields for inverse modelling to constrain bed slipperiness flow history in ice sheet models using data acquired in by the British Antarctic Survey (BAS) Polarimetric radar Airborne Science Instrument (PASIN) in the Institute Ice Stream catchment of West Antarctica.