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The subglacial environment of Evans Ice Stream, West Antarctica from radio-echo sounding

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Airborne ice-penetrating radar (radio-echo sounding) is the most efficient method for investigating subglacial environments across polar ice-sheets. Theoretically, analyses of the shape and amplitude of the basal reflector can yield physical information on subglacial conditions. Most notably, due to the high relative permittivity of liquid water a high amplitude reflection indicates a temperate (unfrozen) bed, whose diagnosis is pertinent for understanding controls on ice dynamics and, in particular, tributary and fast-flow phenomena. However exploiting datasets in this way remains difficult as consistent algorithms for the quantitative analysis of basal reflectors are yet to be established, with perhaps the greatest difficulty being posed by characterising how the ice itself attenuates the radar signal.

In this study we consider this problem using a 150 MHz centre-frequency airborne radar survey of Evans Ice Stream, a major West Antarctic ice stream, collected by the British Antarctic Survey in 2006/07. Using temperature output from a 3D finite difference ice-sheet model we derive a spatially varying parameterisation of englacial attenuation. The peak amplitude of the ice-bed reflection is extracted and corrected for geometric spreading, variations in radar power output and attenuation. We find a clear association with fast flow regions and a bimodal frequency distribution, separated by 10-15 dB, consistent with the reflectivity of the subglacial interface being dominated by the presence of subglacial water. In order to develop these results we present a comparison with a surface roughness metric, based on landscape statistics and a first order analysis of the reflection shape. We discuss the glaciological and geophysical implications of these observations. This study demonstrates the potential for the exploitation of existing radar datasets using relatively straightforward techniques.