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Improved processing, slope estimation, and ice flow interpretation using englacial layer data from radar sounding

Elisa Mantelli (1), Davide Castelletti (1), Dustin Schroeder (1,2), Jenny Suckale (1), and Andrew Hilger (2)

(1) Stanford University, Geophysics, Stanford, United States (emantell@stanford.edu), (2) Stanford University, Electrical Engineering, Stanford, United States

Englacial layers are effectively tracers of internal deformation and ice flow history, and their geometry is known to carry information about features of ice flow that are key to ice sheet modelling. In spite of this, the systematic use of englacial layers to constrain ice flow properties and ice sheet basal conditions has proven challenging, one substantial difficulty being that ice sheet radar data consistently show bands of ice where layers vanish throughout most of the ice column. Current processing approaches present an ambiguity in this respect, in the sense that internal layers can be absent either because they are destroyed by the processing itself, or because they do not exist. By improving the processing in order to exclude the former, the latter can be interpreted physically, thus enhancing our ability to constrain properties of ice flow that are difficult to measure otherwise. In this study we present a novel processing approach for airborne radar data that at the same time corrects for the destructive stacking that is primarily responsible for vanishing englacial layers in airborne surveys, and automatically extracts their local slope without the need for layer tracing. The main advantage of this approach is that under mild assumptions the slope of englacial layers can be mapped to the vertical velocity field, hence it provides a direct constrain for ice flow models. We present applications of this approach to data from Institute Ice Stream (Antarctica), and discuss how information from englacial layers can be used to constrain the physics of basal sliding, ice flow history, and basal topographic effects by means of suitable ice flow models.