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Repeat-pass interferometry applied to englacial layer velocity estimation using radar sounder data

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The vertical englacial velocity structure is an important indicator and result of the dynamic, rheological, and subglacial configuration of ice sheets. Previous studies have measured englacial velocities with invasive and time-consuming techniques using strain gauges and inclinometers installed in boreholes.

More recently, ground-based radar systems (e.g., a-pRES) have been used to measure vertical velocities from the temporal changes in the position and phase of reflections from englacial layers. These stationary ground-based radar systems transmit and received complex electromagnetic signals that penetrate the surface and measure the layer boundaries that correspond to dielectric discontinuities in ice. The phase difference among two acquisition separated in time can be converted in vertical displacement enabling the velocity estimation of each layer. Despite their ability to provide vertical englacial velocity estimates without drilling, these stationary radars only provided englacial velocity information as a single point.

The aim of our work is to demonstrate that the vertical englacial velocity profiles can also be estimated using airborne multi-temporal radar sounding. Airborne radar sounder acquisition can represent a unique opportunity to observe ice sheet dynamics at a wider scale then ground-based radar systems, which could be combined with InSAR-derived surface velocities to estimate the 3D velocity structure of ice sheets. To this end, we propose a processing technique that allows the estimation of the layer vertical displacement at the centimetre scale using airborne radar sounding data by exploiting the phase difference between radar signals acquired on the crossing points repeat tracks.

We present a trade study based on simulations to inform both the radar parameters design (e.g., central frequency, bandwidth and polarimetry configuration) and the acquisition mission planning (e.g., angle between the multi-temporal tracks and number of repeat pass needed) for this approach.