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Automated estimation of englacial radar velocity from zero offset data; implications for glacier bed topography retrieval

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Ground Penetrating Radar (GPR) is widely used on polythermal and temperate glaciers to sound bed topography and investigate the hydrothermal conditions through detection of englacial radar scattering. Water held within micro- and macro-scale pores and ice grain boundaries in ice at the pressure melting point influences the velocity of radar propagation on the scale of the wavelength, and can result in the occurrence of pronounced diffraction patterns in the data. Methods to investigate the water content distribution quantitatively within temperate ice often require the use of multi-offset common mid-point or common source-point survey techniques, which are logistically challenging and expensive. As a result, bed topography estimation is often undertaken using a constant velocity, and, because lateral variations in the the velocity field are unaccounted for, errors in topography are likely.

Here, we present an automated workflow to estimate an englacial radar velocity field from zero offset data and apply the algorithm to GPR data collected on Von Postbreen, a polythermal glacier in Svalbard, using a 25 MHz zero-offset GPR system. We first extract the diffracted wavefield using local coherent stacking to remove scatter and enhance diffractions. We then use the focusing metric of negative entropy to deduce a local migration velocity field from constant-velocity migration panels and produce a glacier-wide model of local (interval) radar velocity. We show that this velocity field is successful in differentiating between areas of cold and temperate ice and can detect lateral variations in radar velocity close to the glacier bed. The effects of this velocity field in both migration and depth-conversion of the bed reflection are shown to result in consistently lower ice depths across the glacier, indicating that diffraction focusing and velocity estimation are crucial in retrieving correct bed topography in the presence of temperate ice.