



Forward modelling of Ground Penetrating Radar and applications in radioglaciology

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Ground Penetrating Radar (GPR) is widely used in glaciology to observe bed topography, subglacial conditions and englacial structures. However, there are often limitations on the interpretation possible due to the inability to ground truth subsurface conditions and through limitations of the standard common offset survey design. Forward modelling of electromagnetic radiation presents an opportunity to calculate the response of a defined model to a specific survey or system. This has the potential to both quantitatively aid the interpretation of glacial GPR datasets, in addition to driving the development of logistically efficient and advanced survey techniques, including multi-offset and polarimetric surveys.

Here, we present an optimised approach to full waveform modelling of electromagnetic radiation for 2.5 dimensional geometries using `gprMax`, an open source finite difference time domain software package. This technique allows 3 dimensional polarisations to be successfully modelled, allowing investigation of the impacts of antenna polarisation and dielectric anisotropy within the ice without the need for large scale 3 dimensional models. We then use this technique to investigate the effects of multi-offset survey receiver density on the velocity analysis and water content estimates from a synthetic polythermal glacier, with models based on field data from a Svalbard glacier. We then discuss the potential of using a forward modelling workflow as a basis for ice-sheet scale synthetic surveys with the aim of comparing current and developing future radar systems and processing strategies to characterise ice properties on a larger scale.