3D diffraction imaging of alpine glacier GPR data

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Ground-penetrating radar (GPR) is an established tool for glaciologists thanks to the excellent propagation characteristics of radar waves in snow and ice and the potential for high-resolution imaging. In this regard, 3D survey methods hold significant promise for studying the internal structure, properties, and dynamics of glaciers. Typically, 3D GPR data collected on alpine glaciers contain a vast amount of diffraction events, which are assumed to be caused by englacial and subglacial meltwater channels and voids. However, the diffracted wavefield typically has low amplitude and is often masked by more prominent arrivals. Standard processing schemes mostly ignore the diffracted energy and tend to focus on the more prominent bedrock reflection. In contrast, our approach specifically targets the diffraction events. By adapting state-of-the-art diffraction separation and imaging methods from the field of exploration seismology, we aim to obtain a comprehensive image of scatterer locations and investigate its correlation with the englacial and subglacial hydrological network.

Our processing workflow coherently approximates the dominant reflected wavefield in a fully data-driven fashion and subtracts it from the data. The remaining diffracted wavefield is then enhanced using local coherent stacking. Finally, the diffraction-only data are migrated to obtain an image of the distribution of subsurface scatterers.

The described workflow is applied to a 3D GPR data set acquired on the Haut Glacier d'Arolla (Valais, Switzerland). We find that our methodology is highly effective at isolating diffractions in glacier GPR data and provides resolved images of the diffracting features, which could be an indication of channel structures. We are currently exploring the application to more extensive 3D data sets that were acquired this summer with our newly developed drone-based GPR system.