3D GPR Diffraction Imaging for the Investigation of Alpine Glacier Hydrology

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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 internal glacier dynamics and hydrology in detail. 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 channels and voids. However, standard processing schemes mostly ignore these features and tend to focus on the more prominent bedrock reflection. 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 glacier hydrology.

The first step in our processing workflow is to extract the largely hidden diffraction energy from the 3D GPR data (i.e., the diffracted arrivals must be separated from the dominant reflections). To this end, we approximate the reflected wavefield in a fully data-driven fashion by means of a coherent stacking scheme that allows for the automatic discrimination between reflected and diffracted contributions. The reflected energy is then subtracted from the data and a second local coherent stacking procedure is applied to further enhance the remaining diffracted wavefield. Finally, the diffraction-only data are migrated to obtain an image of the distribution of subsurface scatterers.

The above-described workflow is applied to a 3D GPR data set acquired on the Haut Glacier d'Arolla (Valais, Switzerland). We achieve contrasted images of the diffracting structures, which could be an indication of channel structures. We are currently exploring the application to further 3D GPR data sets.