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Illuminating the deeper radio-stratigraphy of an alpine glacier using SAR processing

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The internal stratigraphy of alpine glaciers entails information about its past dynamics and accumulation rates. It further can be used for intercalibrating the age-depth scales of ice cores. The internal ice stratigraphy is often imaged using radar, but similar to polar ice sheets the deeper stratigraphy is often difficult to resolve with classical pulsed radar systems. For polar ice sheets, the introduction of phase coherent radars has illuminated this former echo-free zone (EFZ) and now patterns of folded, buckled and disrupted ice stratigraphy are clearly visible. Unfortunately, the new airborne and ground-based radar systems applied in polar regions are typically too heavy to be deployed in an alpine environment.

Here, we transfer the lightweight autonomous phase-sensitive radio-echo sounder (ApRES) to an alpine glacier targeting its echo-free zone (Colle Gnifetti, Italy/Switzerland). The ApRES is a coherent frequency modulated continuous wave radar with an integration time of 1 s per trace which we deployed in combination with a GNSS used in real time kinematic (RTK) mode. The latter allows repositioning of the antennas with sub-wavelength accuracy (approximately 5 cm) required to exploit the coherent signal. Like this, the radio-stratigraphy of the former EFZ at this site could be imaged using a matched filtering SAR method. The resulting radargrams cover former ice core sites (e.g., Ice Memory and KCC) and can be used to harmonize conflicting age-depth scales. This dataset will be analysed further in conjunction with ice-fabric measurements from ice cores to reveal how the anisotropic ice rheology imprints on the flow field of glaciers.