

## **Drone-based GPR system for alpine glacier surveying**

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Ground-penetrating radar (GPR) surveys over glaciers are typically performed either directly on the surface (e.g., on foot, skis, or with snowmobiles), or by helicopter well above it. In the scope of 3D data acquisitions, both techniques have advantages but also drawbacks. While air-based surveys allow the coverage of large areas safely and efficiently, it comes at the expense of reduced resolution of glacier internal structures. On the other hand, ice-based acquisitions offer high-resolution opportunities, but are time-consuming, labour intensive, and dangerous as well. However, recent advances in the development of drone technologies open new data acquisition possibilities, and we have developed a drone-based GPR system that combines advantages of both methods.

Our custom-built GPR instrument uses real-time sampling to record traces of length 2800ns, which corresponds to a depth of over 200m in glacier ice. Each trace is stacked over 5000 times and acquired using a sampling frequency of 320Mhz, the latter which is just enough to avoid aliasing with our single lightweight 70Mhz-center-frequency antenna. Traces are recorded at a rate of 14Hz, meaning that a drone speed of at least 4m/s can be considered while maintaining a sufficient high trace density for high-resolution studies. We performed initial tests on summer 2021 on two Swiss Alpine glaciers and recorded around 100-line kilometers of 3D GPR data, over 11 days of fieldwork. With further development, we are aiming to automatise as much as possible the 3D GPR data acquisitions. And coming back on a regular basis to record data on the exact same area, we might be able to move toward 4D GPR data to investigate temporal glacier variations such as dynamics and hydrology.