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Observing the cryosphere with millimetre wave radar: The case study of Rhône Glacier

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Improving our understanding of the processes governing mass loss from the cryosphere is inhibited by a lack of data at high spatial and temporal resolution. Satellite sensors can provide regional to global scale coverage of glacier processes but fail to resolve processes that occur rapidly, for example glacier calving. To observe these processes, the glaciology community must invest in new techniques that can monitor these processes adequately and fill this major research gap. Here, we will discuss the implementation of an exciting new radar system that is capable of imaging glacial terrain at a high angular resolution and during most weather conditions. The system, named AVTIS2, operates at 94 GHz (~3 mm) and offers a compromise between imaging resolution and penetration through atmospheric obscurants. AVTIS2 scans mechanically across a scene of interest in defined increments of azimuth and elevation angles and generates a 3D data cube of backscattered power. We use a point to maximum power criterion to generate point clouds and construct Digital Elevation Models (DEMs) of the terrain. Because AVTIS2 is a real aperture radar it does not require the phase stability of interferometric radars and can acquire DEMs irrespective of local environmental conditions. In this work, we have used the AVTIS2 radar to map Rhône Glacier in the Swiss Alps, representing the first ever time a millimetre wave radar has been used in this way. To improve our understanding of the performance of AVTIS2 for mapping glaciers, we have characterised the scattering properties of glacial ice at 94 GHz by calculating its Radar Cross Section (RCS). This is key to understanding the performance of AVTIS2 for mapping glaciers. This study represents the first investigation into the reflectivity of ice at millimetre wavelengths and the utility of millimetre wave radar as a surveying tool. We will report on the future application of this instrument in glaciological studies and the unique perspective it can offer.