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94 GHz radar mapping of terrestrial snow cover

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Terrestrial snow cover is a perennial feature throughout the global cryosphere, taking the form of individual snow patches during summer and becoming more spatially continuous in winter. The characteristics and conditions of these snowpacks can be altered by rapid changes in temperature and precipitation, significantly impacting local ecosystems, upland hydrology and snow avalanche risks. In Scotland, for example, monitoring the hazards associated with snowpack alterations is a central focus of the Scottish Avalanche Information Service (SAIS) and is essential to ensuring the safety of local communities, hill walkers and mountaineers. In this context, the development of new remote sensing techniques for snow monitoring will help the SAIS develop avalanche forecasts and potentially without the need to undertake arduous and dangerous fieldwork. Here, we aim to develop the utility of millimetre-wave radar at 94 GHz as a new remote sensing tool for monitoring snowpacks. We use a ground-based 94 GHz, real-aperture system called AVTIS2 which mechanically scans across a scene of interest to generate radar backscatter images and 3D Digital Elevation Models (DEMs). AVTIS2 uses a narrow beamwidth of 0.35° (i.e. a spot size of 6 m per km) and has a maximum range of ~6 km, enabling kilometre-scale mapping at high angular resolution. This radar system has previously been successful in monitoring the topographic changes of volcanic lava domes, measuring the dynamics of active lava flows and quantifying 94 GHz radar backscatter from glacier ice. We aim to deploy the AVTIS2 millimetre-wave radar in the Cairngorms National Park, Scotland, in January/February 2021 and validate our measurements with a co-located Terrestrial Laser Scanner (TLS). Additionally, we will acquire in situ observations of snow properties to gain a better understanding of how 94 GHz radar signals interact with the snowpack. Overall, we will report on the following: (1) the radar backscatter characteristics from a variety of snow surface conditions at millimetre wavelengths; (2) point cloud and DEM differences between AVTIS2 and TLS measurements over snow-covered terrain; and (3) the effect of snowpack properties on radar backscatter and how this can be used to understand snow-associated hazards.