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Hansbreen's calving-driven ice loss derived from seismic data supported by millimetre-wave radar scans and neural networks

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Calving of tidewater glaciers is a key driver of glacier mass loss as well as a significant contribution towards sea level rise. However, this dynamic process is still challenging to quantify. In addition, there are very few direct measurements of calving activity in Svalbard at daily to sub-daily resolution due to the requirement of continuous human labour at the calving front for field studies. Seismic instruments in the vicinity of glaciers offer the potential to circumvent this issue since they record ground motion signals, including those generated by calving events, with an unprecedented sub-second resolution. Such data sets are not affected by site conditions like poor visibility or darkness and, in the case of permanent regional seismological stations, already offer long-term datasets. Despite this, a knowledge gap remains which prevents making a direct link between precise calving volumes and seismic records. This study presents our effort made towards obtaining an estimate of volumetric ice loss from integrating seismic records with 3D millimetre-wave radar measurements of a tidewater glacier calving front. In the summer of 2021, an 8-day long time series of integrated measurements was acquired at the calving front of Hansbreen, South Spitsbergen. It included remote sensing observations from a millimetre-wave radar (AVTIS2), Terrestrial Laser Scanner and time-lapse cameras correlated with a seismic dataset from two local arrays deployed at direct vicinity of calving front and a closeby regional permanent seismological station in Hornsund. Integrating these datasets brings an opportunity to correlate visual observations of calving including volumetric ice loss derived from radar scans with seismic signatures registered at nearby seismic arrays. We explore various parameters that characterize observed calving events and develop a model linking chosen parameters with ice loss using machine learning techniques. Local arrays were installed for a limited time and the calibrated parameters are expected to change spatially. Therefore, we further transfer our approach and integrate decade long records from nearby permanent seismological station. Limiting data to a single station record reduces both the accuracy of estimated ice volume and spatial resolution. However, it enables us to apply detection algorithm trained using observed calvings to decade long records and, consequently, to revisit a decade long history of Hansbreen's calving.

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