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Discriminating glacial and volcanic seismicity at Llaima and Villarrica volcanoes, Chile

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The monitoring of seismic activity at active glacier-hosting volcanoes is challenging as volcanic and glacial earthquakes (i.e. icequakes) can have overlapping characteristics (i.e. frequencies, waveform shape and magnitude). Here we present results from the first study to target glacial activity at active ice-covered volcanoes in the Southern Chile. The primary focus so far has been on Llaima volcano, one of the largest and most active volcanoes in the region while hosting >14 km² of glacial ice on the flanks. We use a combination of automatic multi-station event detection and waveform cross-correlation to find candidate repeating icequakes in seismic data from the permanent volcano monitoring network recorded in early 2019. We identified dozens of low magnitude families of repeating seismic events across two months, the largest of which included over 200 events. These findings are comparable to results from analysis of seismic data recorded at Llaima volcano during the same time period in 2015. The persistent, repetitive nature of these events combined with their waveform characteristics and source locations suggest they originated from multiple sub-glacial stick-slip sources around the upper flanks of the volcano. We also deployed a network of seismo-acoustic sensors at Villarrica volcano in early 2020 to record glacial activity in concurrence with the lava lake and strombolian activity at the summit. We conclude that icequakes at Llaima volcano may be more common than previously thought and has implications for how seismic data at ice-covered volcanoes may be used for assessing future volcanic and glacial hazard potential.