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Identifying icequakes at ice-covered volcanoes in Southern Chile

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Volcanoes and glaciers are both productive sources of seismic activity which may be easily confused for each other, leading to potential missed warnings or false alarms. This presents a challenge for organizations monitoring active volcanoes with glaciers on or near the edifice. Cryogenic earthquakes (i.e. icequakes) have been studied at only a few volcanoes around the world and there is a ready need to develop robust methods for efficiently differentiating them from volcanic events. Here we present results from an ongoing study of icequakes at active ice-covered volcanoes in the Southern Chilean Volcanic Zone. The primary focus of the project so far has been on seismo-acoustic data collected at Llaima volcano, one of the largest and most active volcanoes in the region. The data, recorded in 2015 and 2019, was analysed using a combination of automatic multi-station event detection and waveform cross-correlation to find candidate repeating icequakes. We identified 11 persistent families of repeating events in 2015, and over 50 families in 2019; the largest family containing over 1000 events from January to April 2019. The persistent, repetitive nature of these events combined with their waveform characteristics and source locations suggest they originated from multiple sub-glacial sources on the upper flanks of the volcano. Low levels of volcanic activity at Llaima volcano since 2009 have allowed this clear discrimination of icequake events. We are also targeting Villarrica volcano in early 2020 with a network of seismo-acoustic sensors and to record icequake activity in concurrence with the ongoing eruptive activity at the summit. Altogether, the results from this project so far suggest icequakes may be more common than previously thought and has strong implications for how seismic data at ice-covered volcanoes may be interpreted.