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Long-lasting families of similar events at Cotopaxi volcano between 2013 and 2018

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Cotopaxi volcano (5,897 m) is located in Central Ecuador, 50 km south of Quito. It has a long eruptive history including more than 70 eruptions since 1534 with an estimated VEI between 2 and 4. Its last, low magnitude, eruption occurred in 2015. The summit of the volcano is covered by a glacier down to about 5000 m elevation. The volcano is monitored by the Instituto Geofísico whose monitoring network includes permanent seismic stations. The closest station to the summit (BREF) is located 1 km below the summit (2.2 km distance), about 400 m from the base of the glacier. Additionally, from April to September 2018, we operated a temporary network of 7 broadband stations. This network was shaped like a seismic antenna extending from station BREF up to the base of the glacier. One of the stations was installed on the glacier during several weeks.

We examined data from station BREF, recorded between January 2013 and October 2018, with the aim of identifying families of characteristic similar events. We applied a 3-step procedure including: (1) an automatic detection of transient events, (2) a classification of the detected events into families of similar events and (3) a re-composition of the temporal evolution of the largest families using matched-filtering. This procedure outlined families of Long Period and Volcano Tectonic events related to the 2015 eruption. More strikingly it outlined the presence of numerous long-lasting families which may persist for years. These include events which are typical of the permanent background seismicity recorded at BREF station. To locate events belonging to several of these families which were active during the installation of the seismic antenna, we applied a method based on inter-station waveform cross-correlation. Preliminary results indicate epicentral locations on the glacier with slow apparent propagation velocities across the antenna, corresponding to sources located near the surface. Visual inspection of the waveforms also shows clear propagation effects across the antenna. These results lead to the conclusion that all the largest long-lasting families active in 2018 correspond to Ice Quakes. These may be caused by cracking of the icecap, basal slip or forced water flow within the glacier.

Additionally, the temporal evolution of the families during the 5 years of our study outline a striking feature. While most of these families active in 2015 persisted throughout the 2015 eruption, all of them have been interrupted by the large (Mw=7.8) subduction earthquake which occurred near Pedernales on April 16, 2016, 250 km from the volcano. Following the earthquake, new long lasting families appeared. A comparison of pre- and post- April 16 waveforms shows that the M=7.8 event induced changes in the coda of the waveforms, while the onsets remained highly similar. This indicates that some of the post-Pedernales families are just a continuation of the pre-Pedernales ones. Since the induced waveform changes are important, at this time we could not apply properly coda wave interferometry techniques. However our results suggest that the distal subduction earthquake had a stronger influence on the glacier or its shallow substratum than the 2015 eruption.