Explosion quakes and Long Period events with similar waveforms at Tungurahua volcano (Ecuador)

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Tungurahua is one of the most active volcanoes in Ecuador. It is a large andesitic stratovolcano which has been erupting since 1999. Its activity during recent years is characterized by the occurrence of well-defined eruptive phases lasting from several weeks to months, separated by quiescence periods with a comparable duration range. Eruptive phases include the emission of ash and gases with periods of enhanced activity and the occurrence of Strombolian to Vulcanian explosions that can cause pyroclastic flows. The volcano is monitored by the Instituto Geofisico, whose monitoring networks include 5 broadband stations coupled with acoustic sensors. These instruments record a wide range of seismic signals generated by the volcano. During quiescence periods, mostly LP events and few volcano-tectonic events are observed. During eruptive phases, the seismicity is dominated by the occurrence of tremors, LP events and explosion quakes characterized by the presence of acoustic phases.

We examined the seismicity recorded from August 2009 to December 2010 with the aim to determine the characteristic events among the transients recorded by the seismic monitoring network. For this purpose, an LTA/STA algorithm has been applied to data from a reference station located 4.5 km from the summit in order to identify the transients. The detected signal windows have been classified using cross-correlation to identify families of events with similar waveforms. For each family, a synthetic master event has been generated by stacking the similar waveforms. To recompose precisely the temporal evolution of each family, the different stacks have been used to scan the continuous data using matched filtering.

The procedure indicates a rather reduced number of families as only 6 are identified with more than 5 events. Most of these are families of explosion quakes or LP events active during the eruptive phases which occurred during our study period. The largest include 182 explosion quakes recorded during the May 2010 eruptive phase. Most interestingly, the second largest family with 121 events is active during the entire year 2010, during eruptive phases as well as during quiescence periods. It groups explosion quakes with clear acoustic phases, occurring during enhanced periods of activity, as well as smaller events identified as LP events, occurring during repose periods associated with no surface activity. This result has two possible outcomes. (1) Some of the explosion quakes and LP events at Tungurahua may share a common location and source process such as the resonance of the same fluid column or crack but caused by diverse triggering mechanisms. (2) Alternately, our result may indicate the existence of small undetected explosions at depth during quiescence period leading to no significant surface emissions. In both cases, our result may have important implications in terms of signal interpretation and monitoring.