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Autopsy of the January 2010 eruptive phase of Tungurahua volcano (Ecuador) through coupling of seismo-acoustic and SO2 recordings with ash characteristics

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Tungurahua is an andesitic stratovolcano located in Central Ecuador. It has been erupting from 1999 to 2016 with repeated phases of enhanced activity. Starting in 2008, its activity included the occurrence of distinct eruptive phases separated by periods of quiescence, both lasting from few weeks to months. A great variability of eruptive styles was observed during these phases including Strombolian and Vulcanian explosions, pyroclastic fountaining, continuous ash columns, passive degassing and weak ash emissions. These eruption styles and dynamics are controlled by various parameters including magma supply rate, magma viscosity, volatile content, and the permeability of the conduit. Rapid changes of these parameters can significantly modify the hazards associated to the eruption processes and understanding their relationship with multiparametric geophysical monitoring data can greatly improve our forecasting capacities.

We examined in detail seismic, acoustic and SO2 data, recorded by permanent monitoring networks as well as the characteristics of emitted ashes to track changes in eruption dynamics during a 60-day long eruptive phase that lasted from late December 2009 to March 2010. The comparison of these parameters outlines diverse patterns and correlations among them. We use this diversity to constrain the eruptive processes occurring within the conduit. Typically a variable seismicity may accompany similar degassing rates, depending on conduit conditions. Degassing can freely occur without generating any seismicity if the conduit is open. In contrary, it can generate tremor if the conduit is constricted, or generate larger Vulcanian explosions if it is occasionally or partially closed. Finally, eruptive dynamics may change from continuous degassing to Vulcanian explosions without any significant change in the amount of emitted SO2. The ash emitted under these different regimes actually displays different characteristic textures, morphologies and granulometry, but keeps the same mineralogical and geochemical composition.

Our results outline that multi-parameter monitoring provides a unique insight into the physical processes controlling superficial volcanic activity and offers a potential tool for better understanding volcanoes and detecting changes in their activity.