Comparison of seismo-acoustic and SO2 measurement at Tungurahua volcano (Ecuador) between 2010 and 2012

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Tungurahua is an andesitic volcano located in Central Ecuador that has been erupting since 1999, with repeated phases of enhanced activity during which explosions, ash emissions and occasional pyroclastic flows have occurred. Related to this activity the volcano emits SO2 gas plumes and various seismic signals like tremors and explosion quakes. It is monitored by a network including up to 4 DOAS permanent NOVAC-1 type instruments, 5 broadband seismic stations coupled with infrasound sensors and 6 short period seismometers. We examined the data from these instruments for the period 2010-2012 with the aim of looking for a possible relation between seismic and acoustic recordings and the amounts of SO2 emitted by the volcano.

NOVAC instruments only provide valid measurements under good weather and daylight conditions, leading to intermittent and sometimes sparse time series. Daily average mass fluxes of SO2 have been extrapolated from the available measurements. Alternately, we determined the daily observed SO2 masses by summing all valid recordings during the 10 hours of daily measurement. This approach strongly reduces SO2 measured emissions during quiescence periods and provides time series having an improved correlation on a long time scale with the eruptive phases of the volcano. To complete the characterization of degassing we proceeded in two ways. We first established the acoustic and seismic energies of individual explosions and calculated cumulative daily values. Secondly, to quantify amplitudes of background tremor we calculated median amplitudes over sliding 10-minute windows in different frequency bands.

We compared the temporal evolutions of the different seismic and acoustic parameters with the observed SO2 emission estimates for 4 periods of enhanced activity starting in January, May and November 2010 and May 2011. Since November 2011 until September 2012, the volcano presented an activity characterized by more frequent and shorter periods of explosive activity. In general irregular correlations are found between seismicity and degassing. Often temporal variations in SO2 emissions are poorly reproduced by both tremor and explosion amplitudes, especially in terms of intensity. Large increases in explosive activity are rarely accompanied by large increases in SO2 observed masses (January and May 2010). Degassing may persist despite significant drops in seismicity, including background tremor (May 2010). On the other hand, rough qualitative correlations are sometimes observed between SO2 emissions and explosive activity (November 2010), tremor (November 2011) and sometimes with both tremor and explosions (May 2011). No better correlations are obtained when looking at higher frequency tremor (above 5 Hz) as compared to the dominant 1-5 Hz band. Our results suggest that the relation between seismic activity and SO2 degassing may be strongly controlled by the conditions at the vent.