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Tracking volcanic unrest at Cotopaxi, Ecuador: - the use of the BET_EF tool during an unrest simulation exercise

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As part of the EC-FP7 VUELCO project (#282759), a volcanic unrest simulation exercise for Cotopaxi volcano (5872 m.a.s.l.) has been performed on November 13th 2014 in Quito, Ecuador. The ice-capped stratovolcano, with an andesitic to rhyolitic composition, is one of the most active and hazardous volcanoes in Ecuador. Historic eruptions at Cotopaxi produced large lithic-rich pyroclastic flows, ash flows, lava flows as well as large lahars. Some lahars reached the Pacific Ocean at >200km distance. Recent unrest periods at Cotopaxi occurred in 1975-1976 and 2001 – 2002 and were characterized by increased fumarolic activity, elevated seismicity and edifice deformation that continues today. Fumarolic activity is a concern due to the heat transfer that may affect the ice cover resulting in non-eruptive debris flows.

Here we report on the application of the BET_EF (Bayesian Event Tree for Eruption Forecasting) tool in the simulation exercise. The purpose of its application was to test its value in decision support by providing near-real time probabilities of i) the occurrence of unrest, ii) the origin and nature of unrest and iii) eruptive activity within a time frame of one month. Unlike traditional BET applications where the computational framework is established by expert elicitation long before its application, in Ecuador the tool was run based on an 'ad-hoc' and on the spot set-up of the code. We present the probabilities obtained at each computational node (i.e. unrest – origin of unrest – outcome of the unrest) based on information provided in 5 scientific bulletins provided successively during the simulation exercise. The simulated unrest covered a 4-year period. According to each scientific bulletin provided during the exercise, we have obtained the following results: i) Bulletin 1 – increase seismic activity comparing to background level - Punrest = 0.023; Peruption = 0.003; ii) Bulletin 2 – drastic increase in seismicity, increasing SO_2 emission (5 x background), thermal anomaly observed in crater - Punrest = 1; Peruption = 0.76; iii) Bulletin 3 – increase in VT and LP events, occurrence of tremors; new fumaroles and increased SO_2 emissions with higher thermal anomaly - Punrest = 1; Peruption = 0.89; iv) Bulletin 4 – intense fumarolic activity with increased SO_2 emissions - Punrest = 1; Peruption = 0.73; v) Bulletin 5 – occurrence of hybrid seismic events; constant SO_2 emissions and increasing thermal anomaly at the crater - Punrest = 1; Peruption = 0.85. The eruptive phase started with small Strombolian explosions in a time window of one month after BET_EF reported probability of eruption of 85%.