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Volcanic risk metrics at Mt Ruapehu, New Zealand: some background to a probabilistic eruption forecasting scheme and a cost/benefit analysis at an open conduit volcano

Gill Jolly (1), Laura Sandri (2), Jan Lindsay (3), Brad Scott (1), Steve Sherburn (1), Art Jolly (1), Nico Fournier (1), Harry Keys (4), and Warner Marzocchi (5)

(1) GNS Science, Wairakei Research Centre, Taupo, New Zealand (g.jolly@gns.cri.nz), (2) Istituto Nazionale di Geofisica e Vulcanologia, Bologna, Italy (sandri@bo.ingv.it), (3) School of Environment, The University of Auckland, Auckland, New Zealand, (4) Department of Conservation, Turangi, New Zealand, (5) Istituto Nazionale di Geofisica e Vulcanologia, Roma, Italy

The Bayesian Event Tree for Eruption Forecasting software (BET_EF) is a probabilistic model based on an event tree scheme that was created specifically to compute long- and short-term probabilities of different outcomes (volcanic unrest, magmatic unrest, eruption, vent location and eruption size) at long-time dormant and routinely monitored volcanoes. It is based on the assumption that upward movements of magma in a closed conduit volcano will produce detectable changes in the monitored parameters at the surface. In this perspective, the goal of BET_EF is to compute probabilities by merging information from geology, models, past data and present monitoring measurements, through a Bayesian inferential method.

In the present study, we attempt to apply BET_EF to Mt Ruapehu, a very active and well-monitored volcano exhibiting the typical features of open conduit volcanoes. In such conditions, current monitoring at the surface is not necessarily able to detect short term changes at depth that may occur only seconds to minutes before an eruption. This results in so-called ”blue sky eruptions” of Mt Ruapehu (for example in September 2007), that are volcanic eruptions apparently not preceded by any presently detectable signal in the current monitoring. A further complication at Mt Ruapehu arises from the well-developed hydrothermal system and the permanent crater lake sitting on top of the magmatic conduit. Both the hydrothermal system and crater lake may act to mask or change monitoring signals (if present) that magma produces deeper in the edifice.

Notwithstanding these potential drawbacks, we think that an attempt to apply BET_EF at Ruapehu is worthwhile, for several reasons. First, with the exception of a few “blue sky” events, monitoring data at Mt Ruapehu can be helpful in forecasting major events, especially if a large amount of magma is intruded into the edifice and becomes available for phreatomagmatic or magmatic eruptions, as for example in 1995-96. Secondly, in setting up BET_EF for Mt Ruapehu we are forced to define quantitatively what the background activity is. This will result in a quantitative evaluation of what changes in long time monitored parameters may influence the probability of future eruptions.

The slopes of Mt Ruapehu host the largest ski area in North Island, New Zealand. Lahars have been generated as a result of several eruptions in the last 50 years, and some of these have reached the ski runs in a very short time frame (around 90 seconds from the beginning of the eruption). In the light of these potentially hazardous lahars, we use the output probabilities provided by BET_EF in a practical and rational decision scheme recently proposed by Marzocchi and Woo (2009) based on a cost/benefit analysis (CBA). In such scheme, a C/L ratio is computed, based on the costs (C) of practical mitigation actions to reduce risk (e.g., a public warning scheme and other means of raising awareness, and a call for a temporary and/or partial closure of the ski area) and on the potential loss (L) if no mitigation action is taken and an eruption occurs causing lahars down the ski fields. By comparing the probability of eruption-driven lahars and the C/L ratio, it is possible to define the most rational mitigation actions that can be taken to reduce the risk to skiers, snowboarders and staff on skifield. As BET_EF probability of eruption changes dynamically as updated monitoring data are received, the authorities can decide, at any specific point in time, what is the best action according to the current monitoring of the volcano. In this respect, CBA represents a bridge linking scientific output (probabilities) and Decision Makers (practical mitigation actions).