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Integration of stochastic models for long-term eruption forecasting into a Bayesian event tree scheme

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Eruption forecasting refers, in general, to the assessment of the occurrence probability of a given eruptive event, whereas volcanic hazards are normally associated with the analysis of superficial and evident phenomena that usually accompany eruptions (e.g., lava, pyroclastic flows, tephra fall, lahars, etc.). Nevertheless, several hazards of volcanic origin may occur in noneruptive phases during unrest episodes. Among others, remarkable examples are gas emissions, phreatic explosions, ground deformation, and seismic swarms. Many of such events may lead to significant damages, and for this reason, the risk associated to unrest episodes could not be negligible with respect to eruption-related phenomena. Our main objective in this paper is to provide a quantitative framework to calculate probabilities of volcanic unrest. The mathematical framework proposed is based on the integration of stochastic models based on the analysis of eruption occurrence catalogs into a Bayesian event tree scheme for eruption forecasting and volcanic hazard assessment. Indeed, such models are based on long-term eruption catalogs and in many cases allow a more consistent analysis of long-term temporal modulations of volcanic activity. The main result of this approach is twofold: first, it allows to make inferences about the probability of volcanic unrest; second, it allows to project the results of stochastic modeling of the eruptive history of a volcano toward the probabilistic assessment of volcanic hazards. To illustrate the performance of the proposed approach, we apply it to determine probabilities of unrest at Miyakejima volcano, Japan.

Keywords: Volcanic unrest, Eruption forecasting, Bayesian event tree, Stochastic models, Miyakejima volcano