Geophysical Research Abstracts
Vol. 16, EGU2014-16431, 2014
EGU General Assembly 2014

A Probabilistic Approach of Hazard Mapping for flow-type phenomena. An example of application at Mt. Etna

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The hazard induced by dangerous flow-type phenomena like lava flows, debris flows and debris avalanches can be usefully assessed by analysing a proper set of simulations of hypothetical events characterized in probability. In particular, to map lava-flow hazard, simulations can be performed by assuming a number of nodes from a regular grid of potential vents, selected to uniformly covering the study area. A probability of occurrence can then be assigned to each simulation, based on statistics of historical events and location of each vent with respect to the volcano.

In this study, different hazard scenarios for Mt. Etna (Italy) have been realized, based on computer simulations of lava flows generated by a non-uniform grid of sources. The adopted grid covers the volcano with a variable density of nodes. Five macro-areas can in fact be recognised, in which at higher densities of nodes correspond higher probabilities of vent activation. Moreover, 4 distinct temporal frames have been considered (next 1, 25, 50 and 100 years) and related hazard scenarios have been computed. In addition, the topographic effects of the expected simulation within the considered temporal frames have been analysed, aiming at evaluating hazard trends due to natural morphological changes.

Model parameters, e.g. the probability distribution function for vent activation and for types of eruption (distinguished into classes by duration and volume), have been derived by analysing the past 400-years volcanic history at Mt. Etna. Probabilities of vent activation for the 4 considered scenarios have been computed in terms of total number of expected events per each temporal frame. The actual number of events to be simulated per each scenario has been obtained by considering a Poisson distribution, with the number of expected events in that frame being the mean of the obtained probabilities. For each frame, a total of 240 runs have been performed. Each run is made of the set of simulations expected for the considered scenario, based on a random selection of the vents. Eventually, in order to obtain statistically significant scenarios, the runs have been averaged.

Obtained forecasts point out the areas most exposed to lava-flow hazard at Mt. Etna for the next 1, 25, 50 and 100 years, in case a stationary style of activity can be assumed for the volcano. Trend of hazard can also be appreciated, as well as the effects of natural changing topography due to volcanic activity. The results sound in good agreement with previous studies, but the present method allows for notably reducing the number of simulations needed (and hence the time of computation) and for improving the map details in the worst hazard sectors.