New hazard scenarios for Teide-Pico Viejo Volcano Complex and potential casualty risk curves.

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ABSTRACT

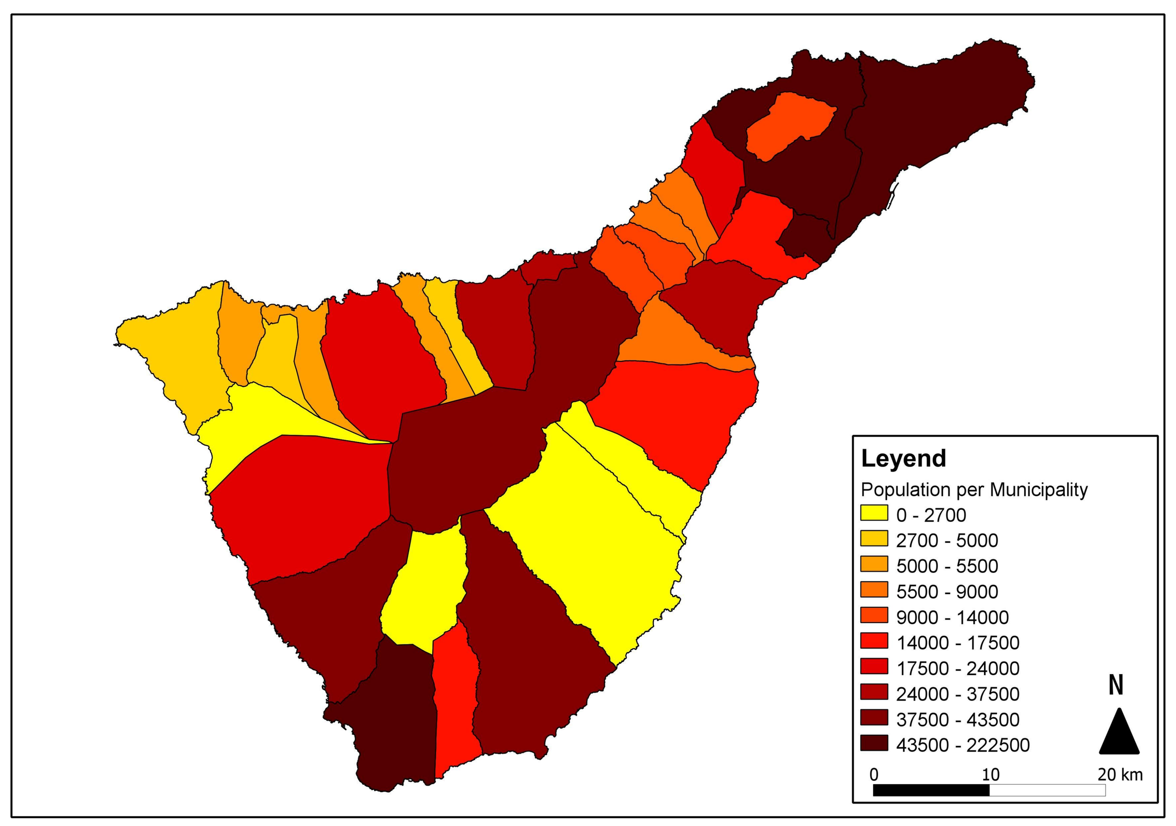
Recent research conducted in the Teide-Pico Viejo Volcanic Complex (TPVVC) shows that the next expected eruption might have a VEI 4. Geochronological data of different volcanic deposits in Tenerife island show that in the last 10,000 years TPVVC has experienced at least 16 eruptions, of which 13 have had a magnitude (Pyle, 2000) equal or greater than 3, based on minimum volumes exposed (García et al., in press). These data make necessary to redefine the more expected eruptive scenario and extend the impact scenario. In this new impact scenario it is necessary to evacuate more than 100,000 inhabitants that could be affected by a likely volcanic eruption. These inhabitants are living in the north valleys as well as some towns located to the west and south of the island.

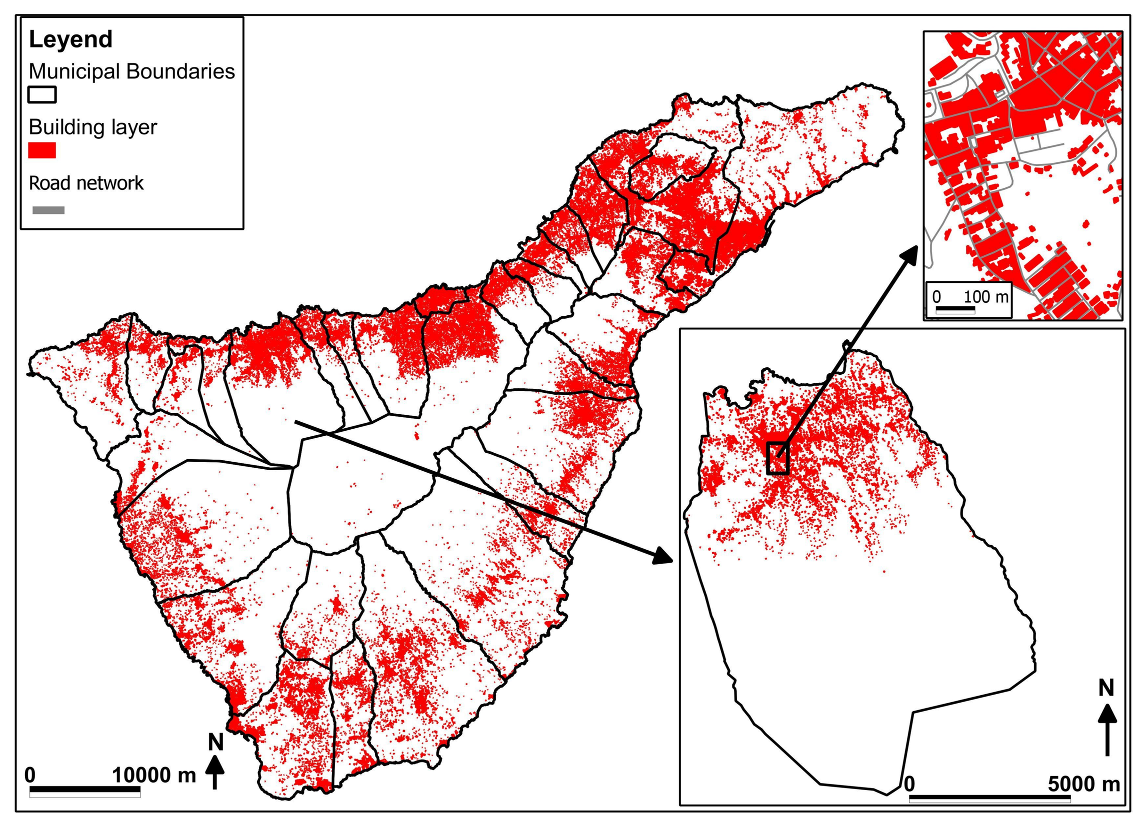
The initial approach (Official Emergency Plan) to use the hotel facilities located in the south of the island as shelters is no longer viable, because it is necessary to perform the evacuation by sea of affected population to other Canary islands. The evacuation of such amount of people requires a highly organization, involving a virtual halt of the island and prepare a contingency plan on the available docks that allow a quick mobilization of people. Furthermore, it is also necessary to evacuate all tourists people from Tenerife and Canary Islands providing not only the closure of the Canarian Island airports due to ash fall, but also the air space around the archipelago and of northern Africa and the Iberian Peninsula.

In this new context, we have calculated Population Risk Curves from simulation of higher risk eruptive scenarios associated with a likely eruption on the Teide-Pico Viejo Volcano Complex. Parameters for simulations were obtained using a statistical model. This model assigns a probability function to the expected VEIs. The eruptive scenarios are simulated as a continuous function of the VEI value. Using a spatial process the eruptive scenarios are joined with the population distribution and results determined how many people are affected in each impact scenarios. Final curves show the probability of potential causalities caused by an expected eruption in one year.

Results show that the number of expected causalities become important starting VEI 3.0 (from 100 to 20000 people with a variation of only 0.5 in the VEI). An increase in the number of expected causalities is obtained with very small variations of the impact scenario probability (0.0003 to 0.0004 for 100 victims and more than 100000). With the current knowledge is impossible to predict between one impact scenario and another, so the Emergency Plan has to take into account the worst-case scenario.

SPATIAL POPULATION DISTRIBUTION





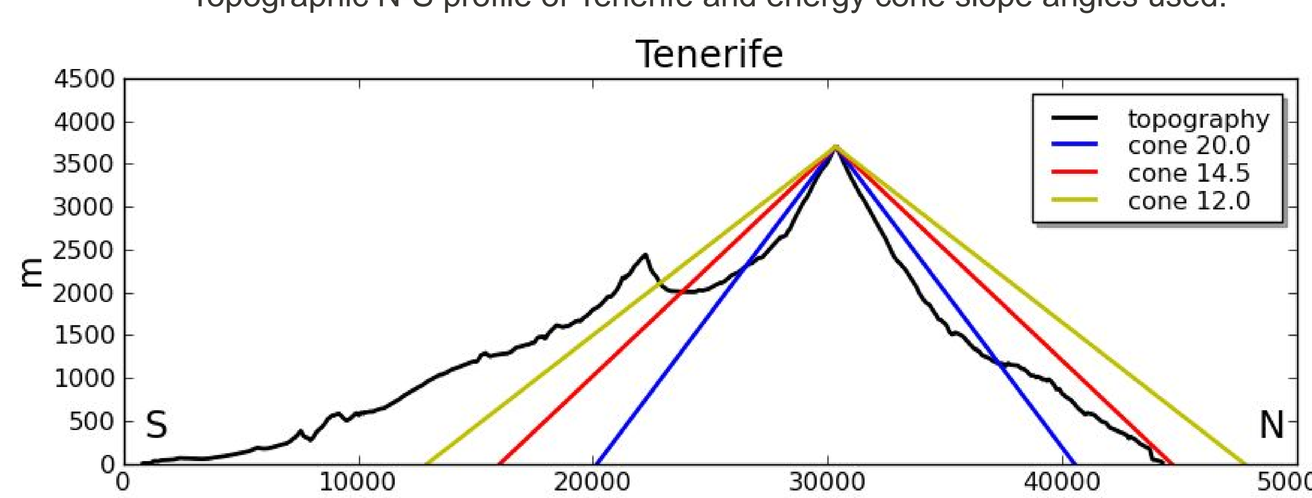
Municipality population is spatially distributed using a building polygonal layer in the GIS. The population is linking to polygon centroids to obtain a simple xyz-point layer. The greater the building polygon area is, the higher the number of inhabitant linking is. The detail-scale of digital cartography used was 1:5000. This xyz-point layer (where z is number of inhabitants) and the eruptive scenario are joined based on spatial location to determine the number of likelihood causalities (impact scenarios). This spatial process is estimate for each obtained eruptive scenario.

PARAMETERS USED IN PDC MODEL

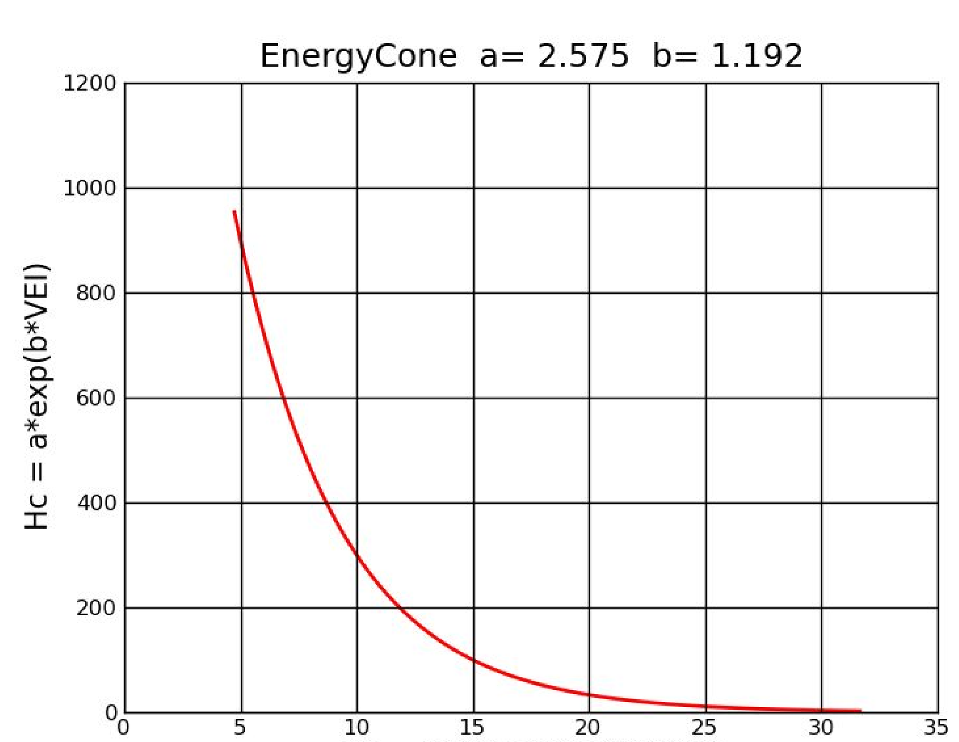
The parameters used in the PDC simulation are based on the Energy Cone Model proposed by Hsü (1975) for rock fall, and modified by Malin and Sheridan (1982) for pyroclastic surges. The tangent of the cone slope angle, Heim coefficient, represents the resistance due to friction (Malin and Sheridan, 1982; Sheridan and Malin, 1983), being the ratio between the vertical descent (DH) over the distance run-out (L). The volume of collapsed material was included as an input parameter in the model (Kaneko and Suzuki-Kamata, 1992, Toyos et al., 2006) from an analysis of the pyroclastic surges of Uzu (Japan) and Sufrière Hill (Montserrat Is.) volcanic eruptions.

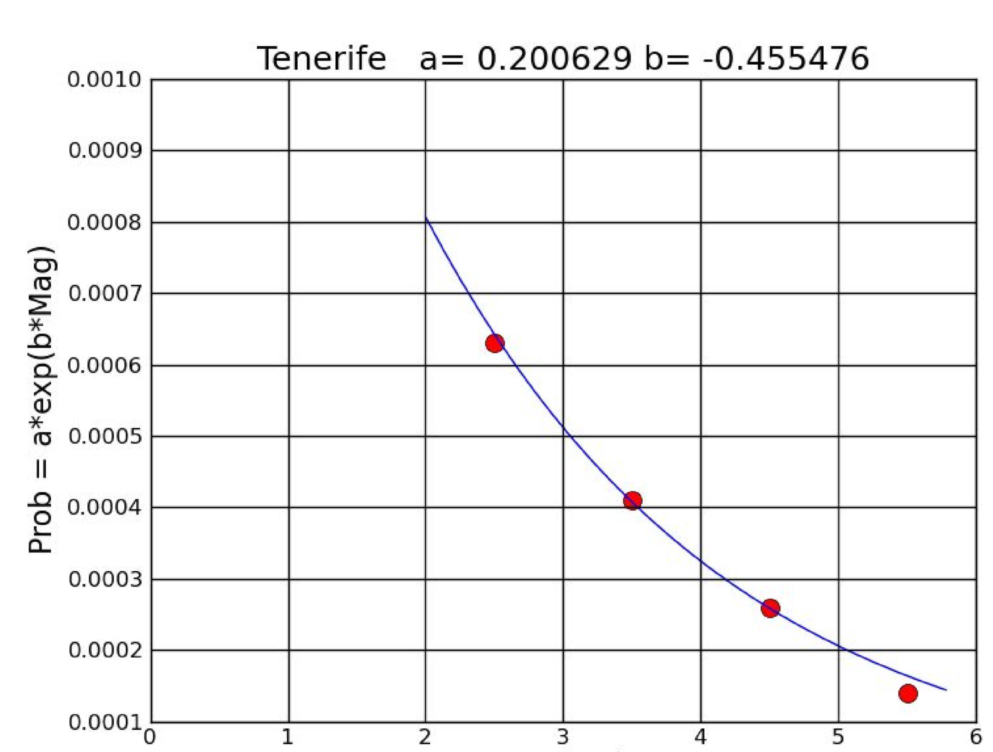
Cone slope angles between 20 and 12 degrees have been used corresponding to Heim coefficients between 0.363 and 0.212, in 250 iterations. To study the stability of the results a simulation was made with values suggested by Alberico et al., (2002) in Campi Flegrei that provides a greater impact to the potential causality effect.

Topographic N-S profile of Tenerife and energy cone slope angles used.



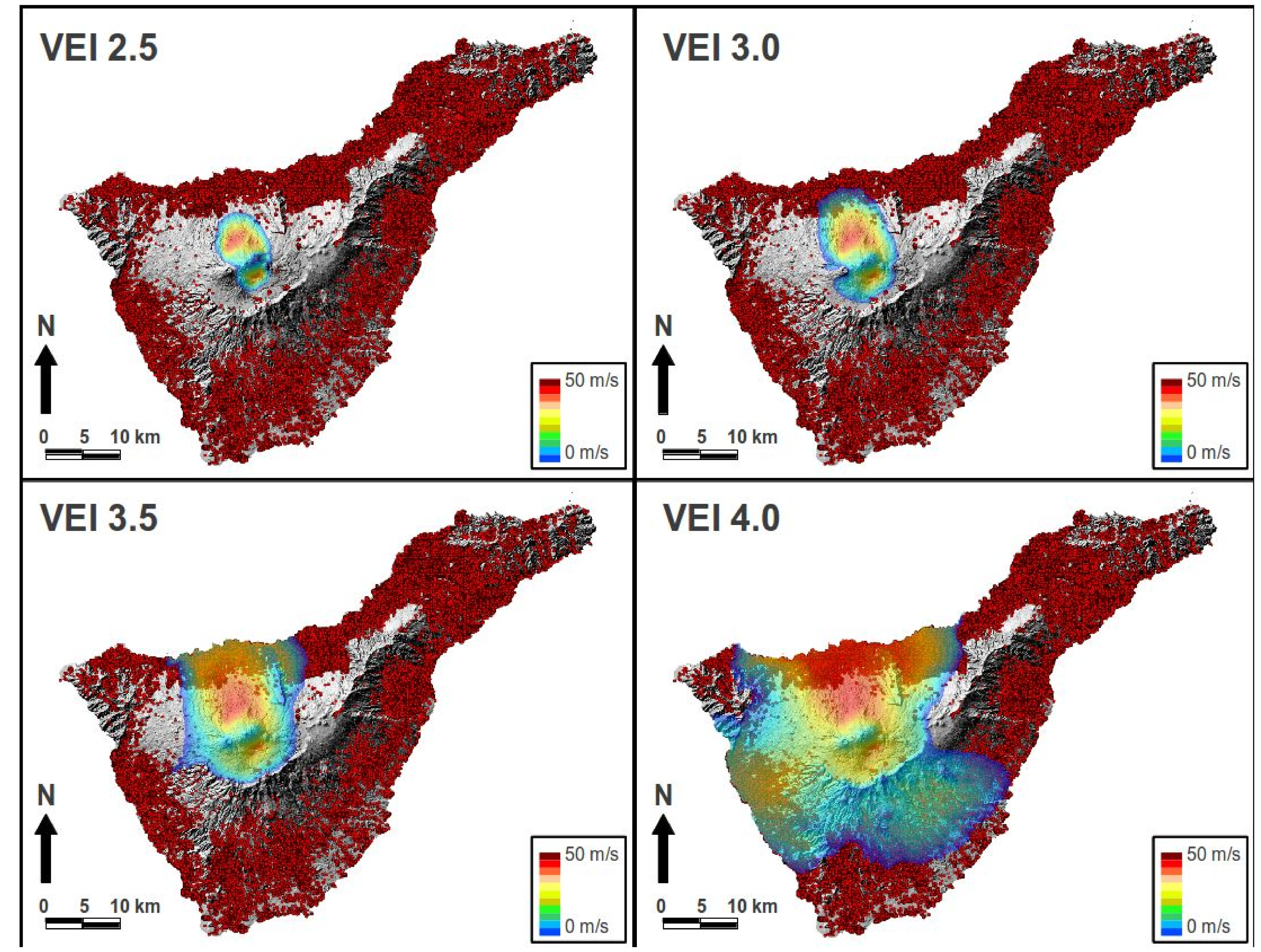
The topography of Tenerife is very abrupt specially on the north flank of the Teide volcano that rises from sea level to 3717 m in less than 15 km (H/L = 0.246) (Figure 3). This high slope leads to abundant block and ash flows, especially on the north slope of Teide reaching the sea.





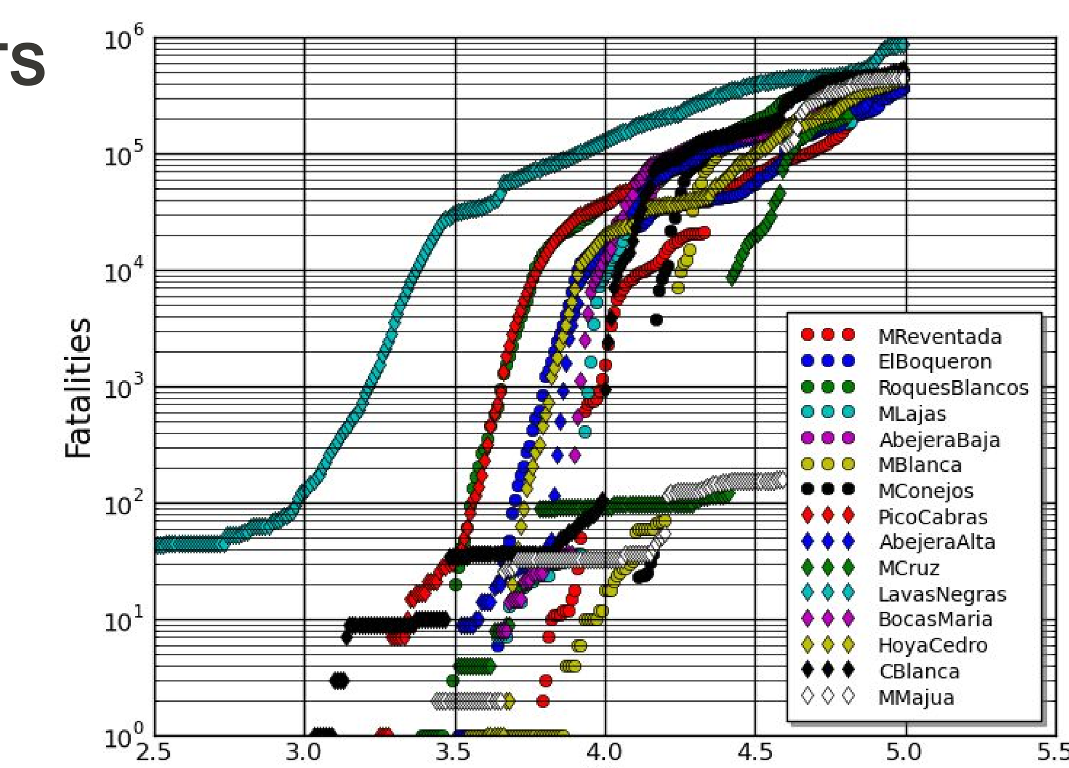
IMPACT SCENARIOS

Simulated impact scenarios for an eruption in Lavas Negras (vent placed at the top of Teide volcano) with VEI 2.5; 3; 3.5 and 4.

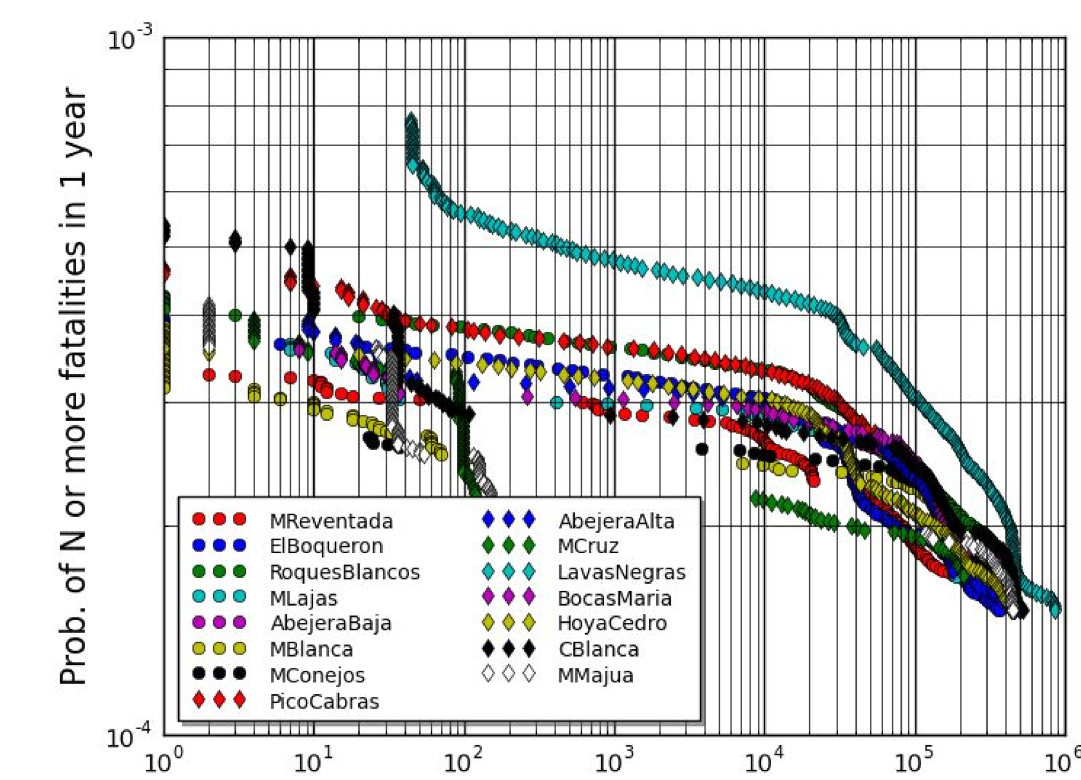


To calculate the hazard scenarios for Tenerife Island with a resolution of 10 m a DEM was employed (GRAFCAN, 1996). An update of the Vorbis Hazard Model (Toyos et al., 2006, Felpeto et al., 2007) was applied. The assigning of scenario probabilities to the Central Volcanic System (CSV) was based on dating by Carracedo et al., (2003, 2007); Sobradelo and Martí (2010) and García et al., (in press). At distances greater than 10 km from the vent and for small magnitudes a high number of fatalities could be expected, due to the sharp slope on the northern flank of Teide volcano. The recent eruption (2010) of Merapi volcano (Smithsonian/USGS, Weekly Volcanic Activity Merapi Report: 3 November - 9 November, 2010), is an example of this phenomenon, where evacuation took place at distances of 20 km from the volcano. Block and ash flows were channelled in the gorges of the volcano and it has been seen that even the finer particles smaller than 1 mm remain in the gorge ([Takahashi and Tsujimoto, 2000])

RESULTS



Potential fatalities versus VEI. Potential fatalities increases rapidly as VEI passes 3, from less than 100 people to more than 20,000 with a variation of 0.5 in VEI.



F-N fatalities exceedance risk curves at 15 different emission centers.

The results obtained indicate that the number of potential fatalities increases rapidly as VEI passes 3, from less than 100 people to more than 20,000 with a variation of 0.5 in VEI. Assigning probabilities to each one of the impacts, a very large increase is obtained in the number of potential fatalities, with a very small decrease in probability (0.0004 for 100 people and 0.0003 for 10,000 people). The application to Tenerife shows that for an eruption in the CVS the expected number of fatalities varies greatly with small variations in probability, making precise forecasting difficult. Other hazards were not considered because would not significantly increase the number of potential fatalities, although a large area would be affected, including other Canarian Islands (i.e. ash fall).

CONCLUSION

It is not technically possible, before the start of eruption, to discriminate between VEI 3 and 3.5, when the monitoring network indicates a possible reawakening of the volcano. In such circumstances, the volcano emergency plan for Tenerife should include the evacuation of more than 100,000 when there are indications of reactivation of the CVS. If it seems the eruption could be at VEI 4 or greater, then the evacuation would be of more than 250,000 people.

The cost of an evacuation of the island of Tenerife would be higher than on the continent, especially for the scenario of greatest probability (magnitude 4). Closing the tourist areas and moving the population to another island would completely paralyze economic activity on the island, even if part of the population were not evacuated. This implies that regardless of the small difference in probability between magnitude 3.5 and 4, differences in cost would be very great.

Acknowledgements

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