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# Spatial probability distribution of future volcanic eruptions at El Hierro Island (Canary Islands, Spain)

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ABSTRACT

The 2011 submarine eruption that took place in the proximity of El Hierro Island (Canary Islands, Spain) has raised the need to identify the most likely future emission zones even on volcanoes characterized by low frequency activity. Here, we propose a probabilistic method to build the susceptibility map of El Hierro, i.e. the spatial distribution of vent opening for future eruptions, based on the probabilistic analysis of volcano-structural data of the Island collected through new fieldwork measurements, bathymetric information, as well as analysis of geological maps, orthophotos and aerial photographs. These data have been divided into different datasets and converted into separate and weighted probability density functions, which were included in a non-homogeneous Poisson process to produce the volcanic susceptibility map. The most likely area to host new eruptions in El Hierro is in the south-western part of the West rift. High probability locations are also found in the Northeast and South rifts, and along the submarine parts of the rifts. This map represents the first effort to deal with the volcanic hazard at El Hierro and can be a support tool for decision makers in land planning, emergency measures and civil defense actions.


## 1. Introduction

El Hierro is an oceanic island located at the south-westernmost point of the Canary Archipelago (Spain), near the African coast in the Atlantic Ocean (Fig. 1a–b). The island is currently in the shield stage of growth, representing the summit of a volcanic shield rising from the seafloor at depth of 4000 m up to 1501 m above the sea level (Carracedo et al., 1999; Münn et al., 2006). On the 10th of October 2011, a submarine volcanic eruption took place in El Hierro, the first submarine eruption reported in 600 years of historical record in the Canary Islands. The new vent is located 2 km offshore at a depth of about 300 m (Fig. 1c), in the submarine flank of the southern rift of the island (Fig. 2). The eruption has severely distressed the island's residents and had negative impacts on tourism and the local economy. The population of El Hierro was under a state of alert from July 2011, when seismic activity began, until the occurrence of submarine eruption in October 2011. This highlights the importance of assessing the volcanic hazard of El Hierro Island in order to reduce and manage its potential volcanic risk, and ultimately contribute to devising appropriate preparedness plans.

There are very few studies on the probability of future eruptions in the Canary Islands. Regarding the probabilistic analysis of volcanic eruption time series, Sobradelo et al. (2011) used a statistical method based on the extreme value theory to compute the temporal probabilities of at least one eruption in a given time interval. As for the long-term spatial probability of vent opening, this has only been estimated in Tenerife Island, using vent locations and vent alignments (Felpeto et al., 2007; Galindo et al., 2007; Martí and Felpeto, 2010). These data were converted into probability density functions (PDFs) and combined by assigning them relevance and reliability values through an elicitation of expert judgment procedure (Aspinall, 2006).

Recently, Cappello et al. (2012) have completed a study on the spatial probability of future flank eruptions at Mt. Etna. The study is based on the possibility of combining the available geological and structural data, highlighting the main pathways of magma transfer, as well as an understanding of their mechanisms, to derive a map of spatial estimates to suggest the most likely emission zones. We use this approach to evaluate the future spatial probability of vent opening at El Hierro. Estimating the probable distribution of future vent locations is an essential step for the volcanic hazard and risk assessment in the island. However, unlike the case of Etna volcano, identifying future eruptive vents in El Hierro implies a great challenge due to the limitations and uncertainties in the available data, including the age, location and magnitude of the eruptions. Nevertheless, we developed a geo-referenced database for long term volcanic hazard analysis in El Hierro based on Geographical Information Systems (Becerril et al., 2009), whose information has been used for this work.

Our knowledge of the structure of El Hierro (Becerril, 2009; Galindo et al., 2012) has allowed identifying and classifying the main structural elements for the statistical analysis. Following the methodology of Cappello et al. (2012), all volcanic structures of the

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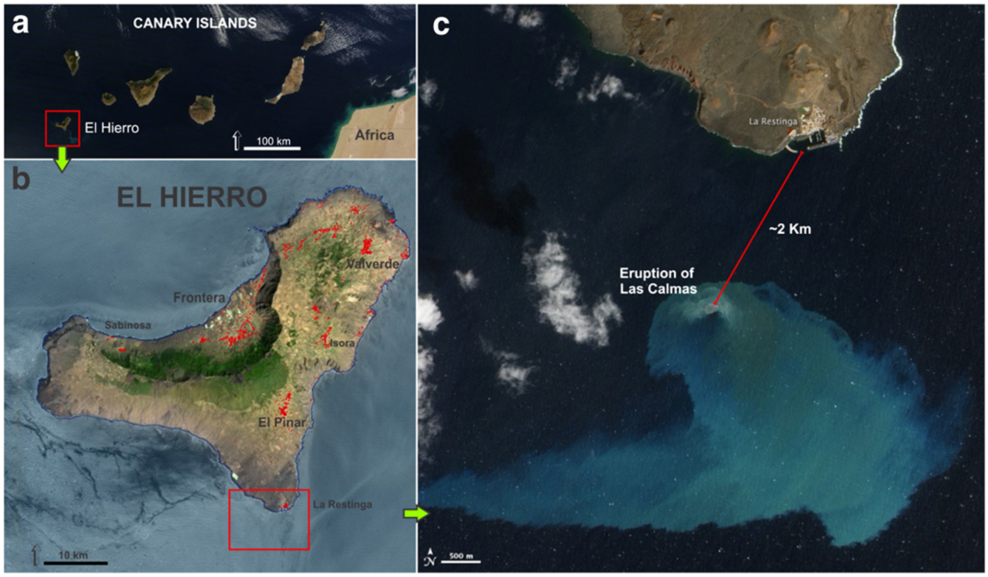


**Fig. 1.** Geographical setting of the Canary Islands (a); main populated areas of El Hierro Island (b); south coast of the Island where the last submarine eruption occurred on 10th of October 2011 (c). NASA Earth Observatory images by Jesse Allen and Robert Simmon, using EO-1 ALI data.

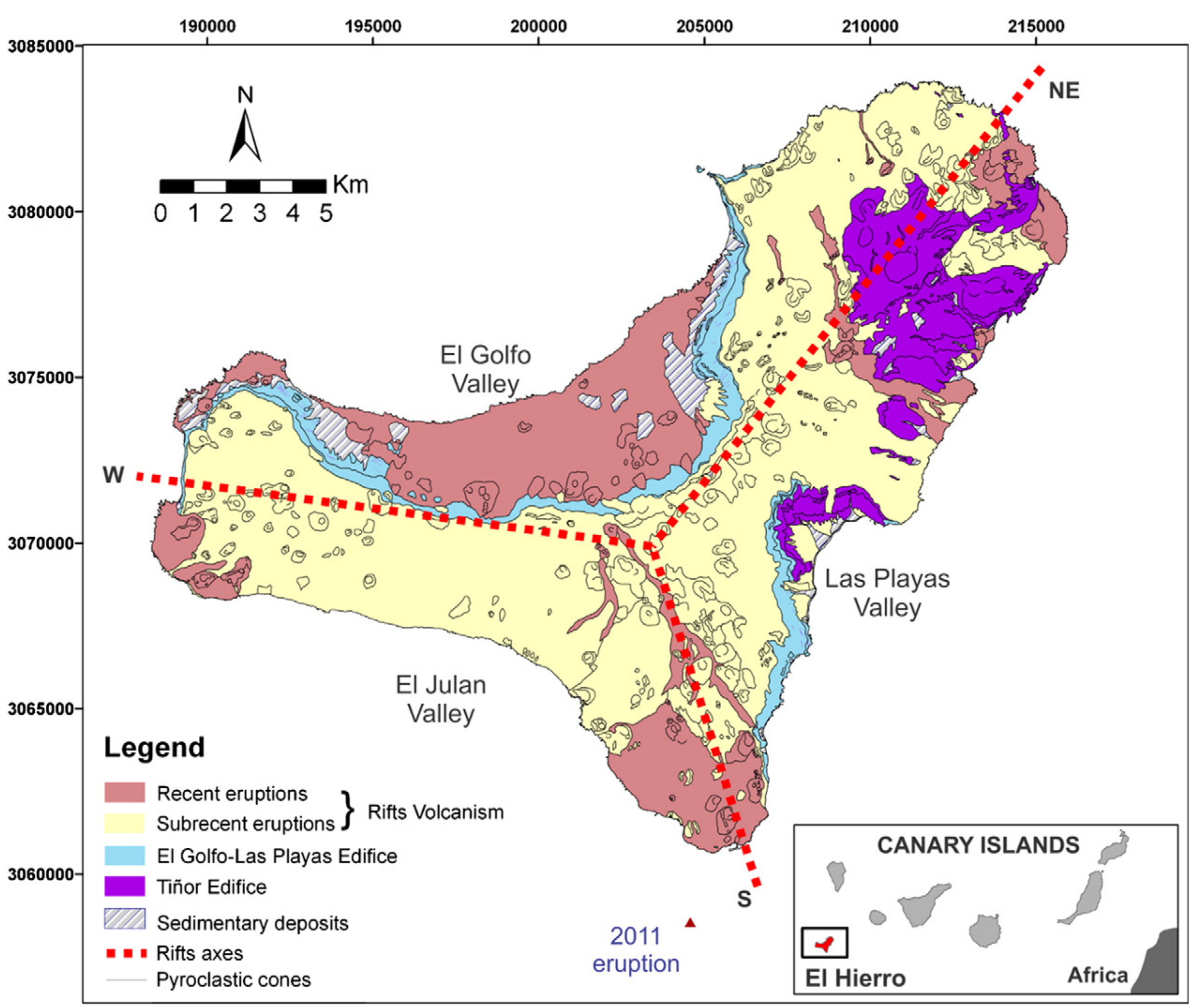


**Fig. 2.** Geological map of El Hierro Island, showing the theoretical rift lines where the majority of eruptions are concentrated. The last eruption of Las Calmas Sea is marked with a dark red triangle. The bottom right inset displays the location of El Hierro within the Canary Archipelago.