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Lava flow hazard map of Piton de la Fournaise volcano

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Piton de la Fournaise, situated on La Réunion Island (France), is one of the most active hot spot basaltic shield volcanoes worldwide, experiencing at least two eruptions per year since the establishment of the observatory in 1979. Eruptions are typically fissure-fed and form extensive lava flow fields. About 95 % of some ~250 historical events (since the first confidently dated eruption in 1708) have occurred inside an uninhabited horse-shoe shaped caldera (hereafter referred to as the Enclos) which is open to the ocean on its eastern side. Rarely (12 times since the 18th century), fissures have opened outside of the Enclos where housing units, population centers and infrastructure are at risk. In such a situation, lava flow hazard maps are a useful way of visualizing lava flow inundation probabilities over large areas. Here, we present a lava flow hazard map for Piton de la Fournaise volcano based on: i) vent distribution, ii) statistics of lava flow lengths, iii) lava flow recurrence times, and iv) simulations of lava flow paths across multi-temporal (i.e., regularly updated) topography using the DOWNFLOW stochastic numerical model. A map of the entire volcano highlights that the most probable (up to 12 %) location for future lava flow inundation is within the Enclos, where about 100,000 visitors are present each year. Hazard distribution changes throughout the analysis period due to the high frequency of eruptions that constantly modifies the vent opening distribution as well as the topography and the lava flow dimensional characteristics. Outside of the Enclos, probabilities reach 0.5 % along the well-defined rift zones and, although hazard occurrence in inhabited areas is deemed to be very low (<0.1 %), it may be underestimated here, as our study is only based on post-18th century records and neglects cycles of activity at the volcano. Specific hazard maps considering different event scenarios (i.e., events fed by different combinations of temporally evolving superficial and deep sources) are required to better assess affected areas in the future – especially by atypical, but potentially extremely hazardous, large volume eruptions. At such an active site, our method supports the need for regular updates of DEMs and associated lava flow hazard maps if we are to be effective in mitigating the associated risks.