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Probabilistic hazard mapping of the pyroclastic density current hazard from sub-Plinian eruptions at Vesuvius (Italy) using novel methodologies to account for the main sources of uncertainty

Augusto Neri and the Speed project Team
Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Pisa, Pisa, Italy (neri@pi.ingv.it, +39 050 8311942)

The aim of this work is to produce probabilistic hazard maps of pyroclastic density currents (PDC) invasion and runout for sub-Plinian eruptions at Vesuvius (Italy) on the basis of field reconstructions and numerical simulations, supplemented by expert judgement. Fieldwork studies have produced detailed stratigraphic analyses of deposits produced by past sub-Plinian events at Vesuvius, such as the AD 1631, 472 and Greenish eruptions. In complementary work, transient and 3D numerical simulations of column collapse events and associated PDC have been carried out for partial and near-total collapse of a sub-Plinian volcanic column. These different strands of empirical and modelling evidence were critically analysed and combined using two expert judgement pooling algorithms: the Cooke "Classical model", and a newly designed point-wise estimation model named ERF (Expected Relative Frequency). These methods were used to account for optimal point-wise estimates, uncertainties, and quantify probabilistic hazard maps. The assessment included consideration of several sources of uncertainty including vent location, eruption intensity (i.e. mass flow-rate), PDC generation mechanism (partial column collapse vs near-total collapse), and the properties of the eruptive mixture and flow. Epistemic and aleatory limitations of the stratigraphic studies and numerical modelling were also accounted for in the elicitation process. The findings reveal, for any vent location area, the wide spread of the probability of flow invasion and maximum runout due to the numerous sources of uncertainty investigated. Moreover, the uncertainty in vent location within the caldera strongly determines the relative probability of pyroclastic flow invasion of different sectors around the volcano, as well as corresponding runouts. The results address the key problem in hazard mapping of how to integrate the main sources of uncertainty, and also raise the question of how to communicate this uncertainty to decision makers.