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Assessing pyroclastic density current hazard from sub-Plinian eruptions at Vesuvius (Italy) and associated uncertainties

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Pyroclastic density currents (PDC) represent a potential enormous risk at Vesuvius. The chances of survival in locations affected by these flows are so low that these areas need to be evacuated in advance of any eruption that produces such flows. The aim of this work is to produce probabilistic hazard maps of PDC invasion and runout on the basis of field reconstructions and numerical simulations, supplemented by expert judgement. Fieldwork studies have produced detailed stratigraphic analyses of deposits produced by sub-Plinian events at Vesuvius, such as the AD 1631, 472 and Greenish eruptions, indicating the areas that were invaded and the maximum distances reached by the flows. 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. Results simulate the complex dynamics of the near-vent collapse and indicate the main effects of volcano topography on propagation of flows. These different strands of empirical and modelling evidence were critically analysed, appraised and combined using two expert judgement pooling algorithms: the Cooke "Classical model", and a newly designed point-wise estimation model named ERF (see Flandoli et al., Proceedings CMG 2010). These were used to account for 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), flow generation mechanism (partial column collapse vs low-fountaining), and the properties of the eruptive mixture and flow. Epistemic limitations of the stratigraphic studies and epistemic and aleatory limitations of numerical modelling were also accounted for in the elicitation process. The findings reveal, for any vent location area, the remarkable spreading 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. Although it is likely, and desirable, that future studies will significantly reduce epistemic sources of uncertainty, the present results address the key problem of how to handle uncertainty, and raise the question of how to communicate it to decision makers.