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Probabilistic volcanic hazard assessments of Pyroclastic Density Currents: ongoing practices and future perspectives

Pablo Tierz (1), Laura Sandri (1), Elena Ramona Stefanescu (2), Abani Patra (2), Warner Marzocchi (3), Antonio Costa (1), and Roberto Sulpizio (4)

(1) Istituto Nazionale di Geofisica e Vulcanologia (INGV), Sezione di Bologna, Italy, (2) Department of Mechanical and Aerospace Engineering, University at Buffalo, USA, (3) Istituto Nazionale di Geofisica e Vulcanologia (INGV), Roma, Italy, (4) Dipartimento di Scienze della Terra e Geoambientali, Università degli Studi di Bari, Italy

Explosive volcanoes and, especially, Pyroclastic Density Currents (PDCs) pose an enormous threat to populations living in the surroundings of volcanic areas. Difficulties in the modeling of PDCs are related to (i) very complex and stochastic physical processes, intrinsic to their occurrence, and (ii) to a lack of knowledge about how these processes actually form and evolve.

This means that there are deep uncertainties (namely, of aleatory nature due to point (i) above, and of epistemic nature due to point (ii) above) associated to the study and forecast of PDCs. Consequently, the assessment of their hazard is better described in terms of probabilistic approaches rather than by deterministic ones.

What is actually done to assess probabilistic hazard from PDCs is to couple deterministic simulators with statistical techniques that can, eventually, supply probabilities and inform about the uncertainties involved.

In this work, some examples of both PDC numerical simulators (Energy Cone and TITAN2D) and uncertainty quantification techniques (Monte Carlo sampling -MC-, Polynomial Chaos Quadrature -PCQ- and Bayesian Linear Emulation -BLE-) are presented, and their advantages, limitations and future potential are underlined.

The key point in choosing a specific method leans on the balance between its related computational cost, the physical reliability of the simulator and the pursued target of the hazard analysis (type of PDCs considered, time-scale selected for the analysis, particular guidelines received from decision-making agencies, etc.).

Although current numerical and statistical techniques have brought important advances in probabilistic volcanic hazard assessment from PDCs, some of them may be further applicable to more sophisticated simulators. In addition, forthcoming improvements could be focused on three main multidisciplinary directions: 1) Validate the simulators frequently used (through comparison with PDC deposits and other simulators), 2) Decrease simulator runtimes (whether by increasing the knowledge about the physical processes or by doing more efficient programming, parallelization, ...) and 3) Improve uncertainty quantification techniques.