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# Modelling the dynamics and hazards of explosive eruptions: Where we are now, and confronting the next challenges (Sergey Soloviev Medal Lecture)

Augusto Neri
Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Pisa Via della Faggiola 32, 56126 Pisa, Italy (augusto.neri@ingv.it)

Understanding of explosive eruption dynamics and assessment of their hazards continue to represent challenging issues to the present-day volcanology community. This is largely due to the complex and diverse nature of the phenomena, and the variability and unpredictability of volcanic processes. Nevertheless, important and continuing progress has been made in the last few decades in understanding fundamental processes and in forecasting the occurrences of these phenomena, thanks to significant advances in field, experimental and theoretical modeling investigations. For over four decades, for example, volcanologists have made major progress in the description of the nature of explosive eruptions, considerably aided by the development, improvement, and application of physical-mathematical models. Integral steady-state homogeneous flow models were first used to investigate the different controlling mechanisms and to infer the genesis and evolution of the phenomena. Through continuous improvements and quantum-leap developments, a variety of transient, 3D, multiphase flow models of volcanic phenomena now can implement state-of-the-art formulations of the underlying physics, new-generation analytical and experimental data, as well as high-performance computational techniques. These numerical models have proved to be able to provide key insights in the understanding of the dynamics of explosive eruptions (e.g. convective plumes, collapsing columns, pyroclastic density currents, short-lived explosions, etc.), as well as to represent a valuable tool in the quantification of potential eruptive scenarios and associated hazards. Simplified models based on a reduction of the system complexity have been also proved useful, combined with Monte Carlo and statistical methods, to generate quantitative probabilistic hazard maps at different space and time scales, some including the quantification of important sources of uncertainty. Nevertheless, the development of physical models able to accurately replicate, within acceptable statistical uncertainty, the evolution of explosive eruptions remains a challenging goal still to be achieved. Testing of the developed models versus large-scale experimental data and well-measured real events, real-time assimilation of observational data to forecast the process nature and evolution, as well as the quantification of the uncertainties affecting our system and modelling representations appear key next steps to further progress volcanological research and its essential contribution to the mitigation of volcanic risk.