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Merging deterministic and probabilistic approaches to forecast volcanic scenarios

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Volcanoes are extremely complex systems largely inaccessible to direct observation. As a consequence, many quantities which are relevant in determining the physical and chemical processes occurring at volcanoes are largely uncertain. On the other hand, the demand for eruption scenario forecast at many hazardous volcanoes in the world is pressing, reflecting into the development and use of increasingly complex physical models and numerical codes. Such codes are capable of accounting for the extremely complex, non-linear behaviour of the volcanic processes, and for the roles of several quantities in determining volcanic scenarios and hazards. However, they often require enormous computer resources and imply long (order of days to weeks) CPU times even on the most advanced parallel computation systems available to-date. As a consequence, they can hardly be used to reasonably cover the spectrum of possible conditions expected at a given volcano. At this purpose, we have started the development of a mixed deterministic-probabilistic approach with the aim of substantially reducing (form order 10000 to 10) the number of simulations needed to adequately represent possible scenarios and their probability of occurrence, corresponding to a given set of probability distributions for the initial/boundary conditions characterizing the system. The core of the problem is to find a "best" discretization of the continuous density function describing the random variables input to the model. This is done through the stochastic quantization theory (Graf and Luschgy, 2000). The application of this theory to volcanic scenario forecast has been tested through both an oversimplified analytical model and a more complex numerical model for magma flow in volcanic conduits, the latter still running in relatively short times to allow comparison with Monte Carlo simulations. The final aim is to define proper strategies and paradigms for application to more complex, time-demanding codes describing the transient, multi-dimensional, multi-component dynamics of volcanic systems.