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Using Bayesian Belief Networks to model volcanic hazards interaction: an application for rain-triggered lahars

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Quantification of volcanic hazards is a challenging task for modern volcanology. Assessing the large uncertainties involved in the hazard analysis requires the combination of volcanological data, physical and statistical models. This is a complex procedure even when taking into account only one type of volcanic hazard. However, volcanic systems are known to be multi-hazard environments where several hazardous phenomena (tephra fallout, Pyroclastic Density Currents -PDCs-, lahars, etc.) may occur whether simultaneous or sequentially.

Bayesian Belief Networks (BBNs) are a flexible and powerful way of modelling uncertainty. They are statistical models that can merge information coming from data, physical models, other statistical models or expert knowledge into a unified probabilistic assessment. Therefore, they can be applied to model the interaction between different volcanic hazards in an efficient manner.

In this work, we design and preliminarily parametrize a BBN with the aim of forecasting the occurrence and volume of rain-triggered lahars when considering: (1) input of pyroclastic material, in the form of tephra fallout and PDCs, over the catchments around the volcano; (2) remobilization of this material by antecedent lahar events. Input of fresh pyroclastic material can be modelled through a combination of physical models (e.g. advection-diffusion models for tephra fallout such as HAZMAP and shallow-layer continuum models for PDCs such as Titan2D) and uncertainty quantification techniques, while the remobilization efficiency can be constrained from datasets of lahar observations at different volcanoes.

The applications of this kind of probabilistic multi-hazard approach can range from real-time forecasting of lahar activity to calibration of physical or statistical models (e.g. emulators) for long-term volcanic hazard assessment.