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# Efficient use of flow simulations for developing probabilistic hazard maps

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It is increasingly understood that development of mathematical models of a geophysical phenomena, while a fundamental step, is only part of the process of modeling and predicting inundation limits for natural hazards. In this work, we combine data from hundreds of observed pyroclastic flows at the Soufriere Hills Volcano, Montserrat, the TITAN2D geophysical flow model, and statistical modeling in order to derive a new methodology for generating probabilistic hazard maps. The initial step consists of estimating probabilities of inundation at particular discrete points of interest (e.g. airport). A key input to the computer model is the probability distribution for the initial volume and direction of the flows based on observed data. A probability distribution of severity and frequency of flow events is derived by combining flow event data, probability modeling, and statistical methods.

Understanding and predicting the effects of volcanic hazards involves understanding the extreme events tail but this is notoriously difficult, especially with limited data and it is prohibitively expensive to compute. Also there is a growing consensus that geophysical flow models with fixed friction parameters cannot model both flows of moderate and large size accurately. However, a full parameter search to determine “best” coefficients utilizing flow simulations is computationally unfeasible. Instead, we use a statistical emulator (or surrogate of the computer model). This computationally cheap response surface approximates the output of the flow simulations, which is constructed based on carefully chosen computer model runs. The speed of the emulator then allows us to ‘solve the inverse problem,’ that is, to determine regions of inputs values (characteristics of the flow) which result in a events of interest (such as one that that reaches a given critical point). The flow frequency distribution is then used to determine the probability of this region, or specifically, the probability that an event of a given magnitude will occur at a particular site. Using quantitative measures like these to solve for the probabilities across an area, zoned maps could be generated from which the authorities can make more informed decisions about hazard mitigation.