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Uncertainty Quantification on the Determination of Debris Flow Run-Out for Quantitative Risk Analysis

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In recent times, a number of dynamic run-out models for debris flows have been developed for risk analysis, for the creation of zonation plans, and for the design of potential mitigation measures. Dynamic run-out models are capable of characterizing the material distribution, the flow intensity, and the zone of potential impact. Estimating the intensity of rapid landslides like debris flows is fundamental for quantifying the hazard on a specific location. Dynamic models allow the effect of released volumes as well as rheological behaviours to be modeled for different scenarios. However, these models are still based on simple assumptions on the physical mechanisms controlling the flow and are based on resistance parameters that cannot be measured directly during an event. As a consequence, these models are associated with large uncertainties, which must be addressed in a proper risk analysis.

This work introduces a systematic identification, characterization and propagation of the uncertainties present in debris flow hazards analysis, with the aim of populating a joint probability density function of the input parameters of a given debris flow model, when conditioned on field observations. From this distribution, likely model responses would allow for generating best estimates and confidence measures of extreme run-out distances. To demonstrate the implementation of this method, a two-dimensional dynamic run-out model is considered that solves the conservation equations of mass and momentum. This general methodology facilitates the consistent combination of physical models with the available observations. Expected outputs like extension, depth and velocity can be used as input into vulnerability and quantitative risk analysis for risk mapping and regulatory zoning. The outlined procedure provides a useful way to produce hazard or risk maps for the typical case where historical records are either poorly documented or even completely lacking, as well as characterizing the confidence limits on the zoning of interest.