UNCERTAINTY IN NATURAL HAZARDS NUMERICAL MODELING

APPLICATION OF AN HYBRID APPROACH TO DEBRIS-FLOWS SIMULATION

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INTRODUCTION

Natural phenomena in mountains put people and assets at risk. Risk level is often described as a combination of hazard and vulnerability. Hazard relates to the intensity and frequency of phenomena while vulnerability concerns damages and values assessment. Risk assessment implies to combine those two components and propose risk reduction measures and strategies. In the debris-flows context, numerical models are used to assess height, speed and extent of flow. Others information sources such as historical data, expert assessments are also used to take a decision about the hazard level. One important issue is therefore to consider in an integrated framework the information imperfection resulting from those heterogeneous sources.

Our problematic is to take into account more faithfully the information quality in the global hazard assessment process. The main goal of this article is to present an other methodology to propagate the uncertainty through numerical simulation models based on an “hybrid” approach: we present and discuss an uncertainty analysis based on a numerical modelling of a debris-flows phenomenon.

BACKGROUNDS : UNCERTAINTY AND SENSITIVITY ANALYSIS

One propagates the known uncertainty concerning the input variables through the model, assessing the uncertainty of the output variables. Thus, the main issue is to assess at best, and as objectively as possible, the input uncertainty. Ideally and in most usual approaches, probability Monte Carlo method is used through density function based on statistical samples. Unfortunately, due to partial knowledge and data, available information about input parameters remains imperfect and often comes from imprecise sources (from expert judgement, for instance) : « we are certain that this avalanche or torrential flood as reached this area, point... », « it is possible that the flood deposit height has been between 1.5 m and 2.5 m... ». In this case, one usually chooses one density function among all those that don’t contradict the available information. Nevertheless, that presupposes, for most imprecise variables, that one adds some information and makes a bet on the real distribution. Different choices for the same variable’s uncertainty will lead to different outputs, and thus influence the decision, unbeknownst to the decision maker. To consider the different aspects of information imperfection, especially its imprecision (lack of information, inaccuracy of measure…), the “Hybrid” method [1,2] of uncertainty analysis has been proposed : this methodology generalises, under some restrictive conditions, the usual Monte Carlo method, by using theories for uncertainty and information management such as probability theory, possibility theory or more generally belief function theory, used as practical tools for coding some imprecise probabilities [3]. For example, possibility distributions appeared to be a flexible tool for eliciting expert knowledge related to debris-flows, volume, rheological parameters...This article extends this approach to a spatial application of hazard assessment, by quantifying the heights and extension hazard through a numerical model for muddy debris flow simulation [4]. Instead of few results, we get a wide range of simulations showing the influence of input data imperfection on results.

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Fig. 1 Examples of spatial extension of debris-flows in the range of imprecise input data chosen by the expert: these two results show the effect of information imperfection

The numerical results induce in each point belief functions synthesized by a P-box (lower and higher probability distributions). They can be used in an information fusion process fused considering many other imprecise sources to take a decision such as defining homogenous risk level areas [5]. A more global methodology is proposed to apply these methods to any simulation model and few criteria of interest, usually reached in safety studies (probability of exceedance, percentiles…).

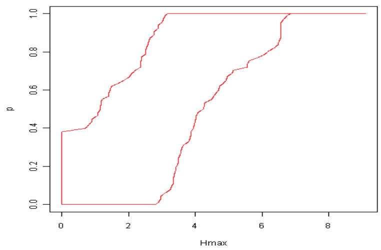

Fig. 2 Examples of a propagation result: P-box bounding the cumulative distribution function of Hmax (maximum height of debris-flows deposition).

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