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Uncertainty and Probability in Natural Hazard Assessment and Their Role in the Testability of Hazard Models

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Probabilistic assessment has become a widely accepted procedure to estimate quantitatively natural hazards. In essence probabilities are meant to quantify the ubiquitous and deep uncertainties that characterize the evolution of natural systems. However, notwithstanding the very wide use of the terms 'uncertainty' and 'probability' in natural hazards, the way in which they are linked, how they are estimated and their scientific meaning are far from being clear, as testified by the last Intergovernmental Panel on Climate Change (IPCC) report and by its subsequent review. The lack of a formal framework to interpret uncertainty and probability coherently has paved the way for some of the strongest critics of hazard analysis; in fact, it has been argued that most of natural hazard analyses are intrinsically 'unscientific'. For example, among the concerns is the use of expert opinion to characterize the so-called epistemic uncertainties; many have argued that such personal degrees of belief cannot be measured and, by implication, cannot be tested.

The purpose of this talk is to confront and clarify the conceptual issues associated with the role of uncertainty and probability in natural hazard analysis and the conditions that make a hazard model testable and then 'scientific'. Specifically, we show that testability of hazard models requires a suitable taxonomy of uncertainty embedded in a proper logical framework. This taxonomy of uncertainty is composed by aleatory variability, epistemic uncertainty, and ontological error. We discuss their differences, the link with the probability, and their estimation using data, models, and subjective expert opinion. We show that these different uncertainties, and the testability of hazard models, can be unequivocally defined only for a well-defined experimental concept that is a concept external to the model under test. All these discussions are illustrated through simple examples related to the probabilistic seismic hazard analysis.