Uncertainties in Seismic Hazard Analysis, High-Dimensional Visualization and Information Theory

Frank Scherbaum, Institut für Erd- und Umweltwissenschaften, Universität Potsdam, Germany

Seismic hazard analysis, in particular in regions of low to moderate seismicity, is known to be subject to large amounts of uncertainties. According to their nature and origin, these can be classified as either aleatory (describing intrinsic variabilities of processes) or epistemic (related to the lack of knowledge). Truely aleatory uncertainties are irreducible and will always be an indispensable part of the hazard calculations. Epistemic uncertainties in contrast, are reducible through gaining knowledge, e. g. through more or better data. At present, epistemic uncertainties in seismic hazard analysis are often treated within a logic tree framework. In this context, models are considered as alternative branches of such a tree. Subsequently, weights are assigned to each branch to express the degree-of-belief of an analysist in the applicability of the corresponding model. One of the drawbacks of current practice is that the models are usually treated on a purely descriptive basis (a nominal scale). This invites creating unintended inconsistencies regarding the weights on the corresponding hazard curves. On the other hand, for human experts it is difficult to confidently express degrees-of-beliefs in particular numerical values such as ground-motion amplitudes. As a consequence, the current approach to assigning weights to logic tree branches is seen as a major source of reducible uncertainties in seismic hazard analysis

In this presentation I will demonstrate for ground-motion models how the model and the value-based perspectives can be partially reconciled by using high–dimensional information-visualization techniques combined with tools from information-theory. For this purpose, Sammon´s mapping and self-organizing mapping can be used to project ground-motion models onto a two-dimensional map (an ordered metric set). Here they can be evaluated jointly according to chosen criteria such as their relative information loss, their proximity in predicting similar ground motions, or even their proximity in terms of contributing to hazard. This approach provides a natural solution to dealing with partially redundant models as well as it provides a unified framework for (Bayesian) model testing. This potentially makes the assignment of logic tree weights consistent with their ground motion or hazard characteristics without having to completely abandon the model-based perspective.