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Toward a New Seismic Hazard Model for Switzerland: Characterization of Synthetic Seismicity Distributions with Spatially Fractal Properties

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The calculation of seismic hazard for a country is the first important step for the definition of a seismic building code. The goal of probabilistic seismic hazard assessment (PSHA) is to quantify the rate of exceeding various ground-motion levels at a site, given all possible earthquakes. A critical step in PSHA is the accurate definition and characterization of relevant seismic sources. This is particularly challenging in low-seismicity regions, because observation periods are relatively short, seismicity is often diffuse, and active faults are difficult to identify. For these reasons, large source zones are commonly used with spatially uniformly distributed seismicity inside. Observed seismicity, however, is generally not uniformly distributed, but reflects seismotectonic forces and tectonic structure. Rather, observed seismicity even in subregions defined as seismic sources is clustered in space: seismicity tends to aggregate on or close to major fault structures. Thus the hypothesis of uniform distribution of events inside a source zone does not relate well to observed seismicity and could overestimate or underestimate the value of ground-acceleration on the PSHA.

Seismicity is a classical example of a complex phenomenon that can be quantified using fractal concepts. In particular, fault networks and epicenter distributions are know to have fractal properties. The fractal dimension is an extension of the Euclidean dimension and measure the degree of clustering of earthquakes.

In this study, we move towards a more realistic characterization of spatio-temporal distribution of seismicity within each source zone. As first step, we quantified differences between different spatial characterization of seismicity and validate a more realistic method for the generation of synthetic seismicity on a source zone as input for PSHA, extending the concepts described in Beauval et al. (BSSA, 2006). We calculate differences in terms of hazard curves (annual probability of exceedance as a function of ground-motion) for synthetic catalogs characterized by a uniform or a clustered distribution of events on a hypothetical square source zone.
Then we apply the method in the case of a typical low seismicity region such as Switzerland. We computed the fractal dimension of the observed seismicity from the ECOS catalog ($D \sim 1.5$) using a box-counting method. Next we generated sets of synthetic catalogs characterized by a given fractal dimension for each source zone of the current PSHA area source model for Switzerland. Finally, from these synthetic catalogs, we compute hazard curves for eight sites in Switzerland, assuming the same activity rate but with the traditional uniform ($D = 2.0$) and various fractal distributions. We find that the assumption of $D = 2.0$ indeed overestimates the resulting hazard even for realistic zonation models. This overestimation is larger for low probability levels; it can typically reach 10 percent.