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Kernel Smoothing Methods for Non-Poissonian Seismic Hazard Analysis

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For almost fifty years, the mainstay of probabilistic seismic hazard analysis has been the methodology developed by Cornell, which assumes that earthquake occurrence is a Poisson process, and that the spatial distribution of epicentres can be represented by a set of polygonal source zones, within which seismicity is uniform. Based on Vere-Jones' use of kernel smoothing methods for earthquake forecasting, these methods were adapted in 1994 by the author for application to probabilistic seismic hazard analysis. There is no need for ambiguous boundaries of polygonal source zones, nor for the hypothesis of time independence of earthquake sequences.

In Europe, there are many regions where seismotectonic zones are not well delineated, and where there is a dynamic stress interaction between events, so that they cannot be described as independent. From the Amatrice earthquake of 24 August, 2016, the subsequent damaging earthquakes in Central Italy over months were not independent events. Removing foreshocks and aftershocks is not only an ill-defined task, it has a material effect on seismic hazard computation. Because of the spatial dispersion of epicentres, and the clustering of magnitudes for the largest events in a sequence, which might all be around magnitude 6, the specific event causing the highest ground motion can vary from one site location to another.

Where significant active faults have been clearly identified geologically, they should be modelled as individual seismic sources. The remaining background seismicity should be modelled as non-Poissonian using statistical kernel smoothing methods. This approach was first applied for seismic hazard analysis at a UK nuclear power plant two decades ago, and should be included within logic-trees for future probabilistic seismic hazard at critical installations within Europe. In this paper, various salient European applications are given.