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How well can we recover the spatial seismicity pattern from a short earthquake catalog using smoothed seismicity?

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Defining area or fault sources to assess seismic hazard is a difficult and often subjective task in low-seismicity regions. Smoothed or gridded seismicity is a method that has been developed to derive the spatial seismicity pattern in a more objective way, based only on known seismicity and not requiring assumption of source geometries. Smoothed seismicity has gained popularity in recent years, but is still mainly applied in more active regions (e.g., California, Italy). We would like to establish whether smoothed seismicity can also be applied to low-to-moderate-seismicity regions. To gain insight in this issue, we consider a source model consisting of area sources with realistic geometries covering part of NW Europe. We assign varying rates of activity to the different area sources, with a-values (normalized to an area of 100,000 km^2) ranging between 2.2 ($\sim$1.6 times lower than the average rate in stable continental regions) and 4.0 ($\sim$1.6 times higher than the observed rate in the Lower Rhine Graben, the most active tectonic structure in NW Europe). Considering the b-value and Mmax to be constant, we thus define a truncated Gutenberg-Richter magnitude-frequency distribution (MFD) for each source. From these MFDs, binned to a magnitude interval of 0.2, we randomly sample inter-event times for each magnitude bin from a Poisson distribution, in order to generate a 100,000-yr catalog. This parent catalog is subdivided into 1000-yr intervals (catalog samples), and further reduced for each magnitude range according to a realistic completeness. For each catalog sample, we compute a smoothed-seismicity grid, fit a truncated Gutenberg-Richter MFD to each grid cell using different methods and assumptions, and determine the fit between the obtained parameters and the a priori ones used to generate the catalog. We investigate the influence of different smoothing parameters (e.g., smoothing kernel, fixed or variable smoothing bandwidth) to determine which performs best in recovering the underlying seismicity pattern. The optimal smoothing is a tradeoff between less smoothing, which leaves "blobs", and more smoothing, which smears seismicity over too-broad areas. We also explore the lower bound on the catalog length that is required, in function of the normalized a-value, to reasonably recover the seismic activity of an area source.