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Modeling seismic hazard in the Lower Rhine Graben using a fault-based source model

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The Lower Rhine Graben (LRG) is an active tectonic structure in intraplate NW Europe. It is characterized by NW-SE oriented normal faults, and moderate but rather continuous seismic activity. Probabilistic seismic hazard assessments (PHSA) in this region have hitherto been based on area source models, in which the LRG is modeled as a single or a small number of seismotectonic zones, where the occurrence of earthquakes is assumed to be uniform. Hazard engines usually model earthquakes in area sources as point sources or finite ruptures in a horizontal plane at a fixed depth. The past few years, efforts have increasingly been directed to using fault sources in PSHA, in order to obtain more realistic patterns of ground motion. This requires an inventory of all fault sources, and definition of their physical properties (at least length, width, strike, dip, rake, slip rate, and maximum magnitude). The LRG is one of the few regions in intraplate NW Europe where seismic activity can be linked to active faults. In the frame of the EC project SHARE ("Seismic Hazard Harmonization in Europe", http://www.share-eu.org/), we have compiled the first parameterized fault model for the LRG that can be used in PSHA studies. We construct the magnitude-frequency distribution (MFD) of each fault from two contributions: 1) up to the largest observed magnitude (M=5.7), we use the MFD determined from the historical and instrumental earthquake catalog, weighted in proportion to the total moment rate, and 2) the frequency of the maximum earthquake predicted by the fault model. We consider the ground-motion prediction equations (GMPE) that were selected in the SHARE project for active shallow crust. This selection includes GMPE's with different distance metrics, the main difference being whether depth of rupture is taken into account or not. Seismic hazard is computed with OpenQuake (http://openquake.org/), an open-source hazard and risk engine that is developed in the frame of the Global Earthquake Model (GEM). Compared to other commonly-used, non-commercial hazard engines, OpenQuake offers better support for fault sources with simple or complex geometries. We compute hazard maps for return periods of 475, 2375, and 10,000 yr, and compare the results with hazard maps based on area sources. In addition, we conduct sensitivity tests to determine the impact of various parameter choices, e.g. maximum magnitude, inclusion of a background zone to account for lower magnitudes, and GMPE distance metric.