Testing the applicability of GMPEs for the Hainaut region (Belgium) using macroseismic intensity data

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In the area around Belgium, the Hainaut region is one of the most seismically active zones, behind the Roer Valley Graben (where seismicity is linked to known active faults) and the Eastern Ardennes (where the largest historical earthquake in NW Europe occurred). As a result, this comparatively small area stands out on most seismic hazard maps made during the past two decades. However, seismicity only started at the end of the 19th century and seems to decline gradually since the late 20th century. Historical earthquakes are not known in this area. This evolution is very similar to the history of coal mining in the area, which started in the 19th century, culminated in the 20th century and ceased in 1984, suggesting that the Hainaut seismicity may be induced. This seismicity is characterized by low to moderate magnitudes, up to M_W= 4.1, but due to their shallow focal depth (< 6 km), many earthquakes caused damage with corresponding maximum intensities up to VII on the EMS-98 scale, as indicated by a recent compilation of all available macroseismic intensity data (Camelbeeck et al., 2021). This reassessment also showed that intensities in this region attenuate much faster with distance than in other parts of Belgium. This highlights the importance of selecting appropriate ground-motion prediction equations (GMPEs) for seismic hazard assessment (SHA), which is the main objective of this study.

The past two decades, several metrics have been proposed to evaluate the goodness of fit between a GMPE and observed ground motion, such as the LH and LLH measures (Scherbaum et al., 2004; 2009) and Euclidean-based Distance Ranking (Kale & Akkar, 2013). Using macroseismic data to rank GMPEs requires an additional conversion of predicted ground motions to intensities using a ground-motion-to-intensity conversion equation (GMICE). Normalized residuals between observed and predicted intensities are then computed using the combined uncertainty of GMPE and GMICE (Villani et al., 2019). We evaluated different GMICEs and selected the relation by Atkinson & Kaka (2007) because it includes magnitude- and distance-dependent terms that result in better consistency between PGA and PGV than with the other relations. We made a selection of 20 recent GMPEs for the analysis, including newer versions of GMPEs used earlier in Belgium, GMPEs applied in recent SHAs in France, Germany and the UK, as well as two GMPEs developed specifically for induced earthquakes. Our preliminary results indicate that the latter GMPEs, in addition to the NGA-East GMPE by Atkinson & Boore (2006), show the best agreement with the data, although it should be noted that none of the tested GMPEs provides a really good match and none of the ranking methods considers the trend of residuals with distance. We also find that the scores based on PGV are significantly better than those based on PGA. The ranking results will be used to guide our selection of GMPEs for the new seismic hazard map of Belgium.