Sensitivity of the Seismic Hazard Maps to the Selected Ground Motion Models: A Case Study of North Iceland

Milad Kowsari[1] and Benedikt Halldorsson[1,2]

Abstract

The Tjörnes Fracture Zone (TFZ) in north-eastern Iceland, is one of the most active seismic zones in northwestern Europe. In this region, most of the earthquakes take place on two separate structures, the Grímsey Oblique Rift (GOR) to the north and the Húsavík–Flatey Fault zone (HFFZ) to the south. The HFFZ is the largest transform fault in Iceland that is located in the close vicinity of Húsavík, the second largest town in North Iceland. Therefore, this region is prone to severe earthquake damage and a careful evaluation of the earthquake hazard is vital. However, previous seismic hazard studies for this region have relied on a single ground motion model (GMM) and incorporated uncertainties in a limited way. In this study, we perform a probabilistic seismic hazard analysis (PSHA) based on the previous site-specific hazard studies for North Iceland, specifically regarding delineation of seismic sources and seismicity parameters. We apply multiple GMMs that have been proposed and used for PSHA in Iceland in the past. We show that the variability in the hazard estimates is quite large, which is a direct result of the inconsistency in the GMMs used in previous studies. In contrast, we re-evaluated the variability of PSHA for North Iceland based on new empirical Bayesian GMMs that not only satisfy all the conditions required for use in PSHA, but also fully capture the characteristics of the existing Icelandic ground motion dataset and in addition contain elements that account for the saturation of near-fault peak ground motions at large magnitudes. The results show that the confidence in the PSHA values is significantly increased using the new models vs. the older ones. The confidence of the PSHA values is quantified through the coefficient of variation. The confidence is shown to be largest over distance ranges where data is most abundant. On the other hand, the confidence decreases considerably at near-fault and far-field distances, primarily because of lack of data for those distances. The findings highlight the importance of using appropriate GMMs for PSHA in Iceland and the need for a revision of the PSHA using not only the new GMMs, but also physics-based seismic source models.

Keywords: Tjörnes fracture zone, PSHA, Bayesian GMMs, Physics-based seismic source models

[1] Faculty of Civil and Environmental Engineering, School of Engineering and Natural Sciences, University of Iceland, Reykjavik, Iceland. Emails: M.K.: milad@hi.is; B.H.: skykkur@hi.is

[2] Geoscience Research Group, Division of Processing and Research, Icelandic Meteorological Office, Reykjavik, Iceland. Email: benedikt@vedur.is