New 3D fault system models of the two transform zones of Iceland for physics-based seismic hazard assessment

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The rate of plate motion in Iceland drives the seismic activity of the two large transform zones in Iceland, the South Iceland Seismic Zone (SISZ) in the southwest and the Tjörnes Fracture Zone (TFZ) in the north. The SISZ is well known for its „bookshelf" style of faulting on an array of strike-slip faults oriented near perpendicular to the long axis of the zone. Recently, this faulting system has been shown to be continuous from the SISZ and all along the Reykjanes Peninsula Oblique Rift zone (RPOR). Moreover, the bookshelf faulting is thought to dominate the long-term release of tectonic strain over the entire SISZ-RPOR transform zone. The larger TFZ is more complex, characterized primarily by two features, the Grímsey Lineament and Grímsey Oblique Rift zones vs. the Húsavík-Flatey Fault Zone (HFFZ). The former can be described as a mirror image of the SISZ-RPOR bookshelf system while the HFFZ is a unique feature, a long strike-slip fault zone striking parallel to the vector of plate motions.

We have constructed new physics-based 3D fault models of the strike-slip fault systems of the SISZ-RPOR and TFZ, respectively. The models have been calibrated on the basis of first-principles to the rate of plate motions in Iceland and account for the systematic spatial variation of the seismogenic potential of the zones, modeled by distinct subzones. The fault systems are completely specified in terms of their fault locations, fault dimensions, maximum expected magnitudes and the long-term slip-rate on each fault. The sensitivity of the fault systems to their key parameters have also been evaluated and their total long-term seismic moment rates are completely consistent with other estimates in the literature based on various earthquake catalogues for the transform zones. Moreover, we have constructed simple seismic area source models of each subzone and calibrated them to the average slip-rates of each sub-zone of the 3D models. The sub-zones can thus also be completely specified by their maximum magnitudes and zone-specific magnitude-frequency relationships (MRF, i.e., Gutenberg-Richter). The total MFRs for the SISZ-RPOR are in complete agreement with the earthquake catalogue and incorporate uncertainty measures. The same comparison for the subzones of the TFZ is underway.

The new 3D fault system models now enable the first comprehensive and physics-based revision of probabilistic seismic hazard assessment (PSHA) in the transform zones of Iceland, that can take advantage of advanced earthquake rupture modeling techniques. A consistent PSHA using standard engineering approach can also simply be obtained via the equivalent seismic area source MRFs. By evaluating the MRFs for the remaining seismic and volcanic areas of Iceland using the ICEL-NMAR catalogue, we have presented a simplified but complete and hybrid area source zone model for Iceland for PSHA applications. This model is the foundation of the latest European seismic hazard model (ESM20) efforts of PSHA in Iceland.

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