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Operational earthquake forecasting in the South Iceland Seismic Zone: improving the earthquake catalogue

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A major earthquake sequence is ongoing in the South Iceland Seismic Zone (SISZ), where experts expect earthquakes of up to MW = 7.1 in the coming years to decades. The historical seismicity in this region is well known and many major faults here and on Reykjanes Peninsula (RP) have already been mapped. The faults are predominantly N-S with right-lateral strike-slip motion, while the overall motion in the SISZ is E-W oriented left-lateral motion. The area that we propose for operational earthquake forecasting(OEF) contains both the SISZ and the RP.

The earthquake catalogue considered for OEF, called the SIL catalogue, spans the period from 1991 until September 2013 and contains more than 200,000 earthquakes. Some of these events have a large azimuthal gap between stations, and some have large horizontal and vertical uncertainties. We are interested in building seismicity models using high-quality data, so we filter the catalogue using the criteria proposed by Gomberg et al. (1990) and Bondar et al. (2004). The resulting filtered catalogue contains around 130,000 earthquakes.

Magnitude estimates in the Iceland catalogue also require special attention. The SIL system uses two methods to estimate magnitude. The first method is based on an empirical local magnitude (ML) relationship. The other magnitude scale is a so-called "local moment magnitude" (MLW), originally constructed by Slunga et al. (1984) to agree with local magnitude scales in Sweden. In the SIL catalogue, there are two main problems with the magnitude estimates and consequently it is not immediately possible to convert MLW to moment magnitude (MW). These problems are: (i) immediate aftershocks of large events are assigned magnitudes that are too high; and (ii) the seismic moment of large earthquakes is underestimated. For this reason the magnitude values in the catalogue must be corrected before developing an OEF system. To obtain a reliable MW estimate, we calibrate a magnitude relationship based on attenuation relations derived for earthquakes in Iceland (Pétursson and Vogfjörd, 2010) and use this relationship to address the problem of underestimating seismic moment for larger earthquakes (>3.0). Finally, to solve the problem related with the overestimation of aftershock magnitude of large earthquakes about 150 earthquakes were checked. All such passages demonstrate the importance of carefully checking the catalogue before proceeding with the operational earthquake forecasting.

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