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Retrospective challenges of earthquake rate models for Europe and Middle East

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The 2013 European Seismic Hazard Model (ESHM13) and the 2014 Earthquake Model of Middle East (EMM14) provide the basis to analyze, compare and discuss the earthquake rate forecast of Europe and Middle East, respectively. The earthquake rate models as developed within ESHM13 (http://www.share-eu.org) and EMM14 (http://www.emme-gem.org), combine multidisciplinary data (tectonics, active faults and harmonized earthquake catalogues) to forecast the location, size and rate of future earthquakes for use within probabilistic framework of seismic hazard assessment (PSHA).

We present an overview of the spatial and temporal characteristics of the unified ESHM13/EMME14 earthquake rate model. The latter, consists of 685 area sources and 1300 active faults, fully harmonized without cross-border limitations. Overall, large statistical variability of earthquake recurrence rates is observed. Completeness of earthquake catalogue, declustering techniques and seismic source delineation are the key factors inflating the statistical estimation of the earthquake recurrence rates. In fact, the limited number of small magnitude earthquakes in early periods and/or lack of large magnitude earthquakes make the seismicity rates highly uncertain. This effect is evident for low seismicity regions (Central and Northern Europe) where the length of the historical observations is short, lacking large magnitude earthquakes, hence inadequate to identify a complete earthquake cycle. The resulting seismicity rates for such regions are problematic, and we emphasize the need of alternative data or models (e.g. strain models) to complement the short-term observations.

Estimation of seismicity rates marginally improves for regions of well identified tectonic structures (i.e. North Anatolian Fault, Dead Sea Fault, Hellenic Arc), where the observed seismicity can be combined with active faults. The latter, provide information on the size and recurrence of large magnitude events as the slip rates may cover one or more seismic cycles with information dating back to hundreds years. The assumption is supported by the seismic moment balancing, which indicates that for seismically active regions, the total seismic moment due to fault slip-rates is greater than the seismic moment from seismicity. However, additional uncertainties are associated with the fault characterization, including the fault geometry, slip-rate values, maximum magnitude, coupling factor, and regional b-values. Finally, we also discuss these uncertainties as well as their propagation to final seismic hazard results.