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Short communication

The SHARE European Earthquake Catalogue (SHEEC) for the time period 1900–2006 and its comparison to the European-Mediterranean Earthquake Catalogue (EMEC)

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Abstract This short communication describes the differences of the seismicity data file of the SHARE European Earthquake Catalogue (SHEEC) from 1900 to 2006 in comparison to the European-Mediterranean Earthquake Catalogue (EMEC) by Grünthal & Wahlström (J Seismol 16: 535–570, 2012). SHARE is the EC project Seismic Hazard Harmonization in Europe. Differences occur in the very north of the study area, in Greece and adjacent areas, and with respect to local volcanic earthquakes at Etna, Italy.

Keywords Earthquake catalogue • Europe • Magnitude

1 Introduction

Earthquake catalogues are one of the basic inputs of seismic hazard assessments. The EC project SHARE (Seismic Hazard Harmonization in Europe), running basically from 2009 to 2012, with the main objective to produce a seismic hazard model for Europe (www.share-eu.org), is based, what concerns the seismicity input, on the SHARE European Earthquake Catalogue (SHEEC). The part of SHEEC for the period 1000–1899 has been prepared in the frame of the project described by Stucchi et al. (2012) involving many collaborators.

In an early phase of the project it was decided that SHEEC for the period 1900–2006 should be provided by the earthquake catalogue being under preparation at that time in the frame of an independent industry financed project at the GFZ German Research Centre for Geosciences. This catalogue was published as European-Mediterranean earthquake catalogue (EMEC) by Grünthal & Wahlström (2012, later on in the text referred as G&W12) and released under www.gfz-potsdam.de/EMEC. EMEC covers basically the time span 1000–2006 with $M_w \geq 3.5$ for events with latitude of epicentral location $\geq 44^\circ\text{N}$ and $M_w \geq 4.0$ for events with latitude $< 44^\circ\text{N}$. The way the data in EMEC were compiled according to a strict hierarchy within 37 polygon areas and how harmonized M_w for all entries have been generated, are described in detail in G&W12. EMEC covers a slightly larger area than SHEEC, notably including northern Africa (see chapter 2). EMEC contains more than 45,000 earthquake entries with some 40,600 in the period 1900–2006. Both SHEEC and EMEC give harmonized M_w magnitudes.

At the final stage of SHARE and even after the due date of catalogue delivery within this project in April

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2011, a few requests were made by the regional representatives in the project to modify the provided EMEC data base 1900-2006 for SHARE. These modifications are restricted to regions in the very north, Greece and surroundings, and a small spot of the Etna volcano. This short contribution describes these modifications, which are - with the exception of Greece - of minor nature.

2 Comparison between the data sets of SHEEC and EMEC for the period 1900-2006

The SHEEC file for 1900-2006 is basically a subset of the EMEC file of the same period with certain easily describable modifications. The presentation of these differences is the subject of this chapter.

A principle difference between the two data files is the areal coverage. The catalogue area of SHEEC is substantially smaller in its western, southern, and eastern parts, as illustrated in Fig. 1. Only in the north, i.e., within the Arctic offshore region, there is a very minor area where the SHEEC coverage exceeds that of EMEC.

After the delivery of the EMEC data for SHARE, the area covered by SHEEC was slightly modified in the

northernmost part (see Fig. 1). These extended areas were filled with data from the EMEC database enriched by several earthquake entries provided by Bungum (pers. communication). Additional changes for the Arctic Ocean and the Kola Peninsula as well as for Karelia are of minor nature. Further modifications were required for a very localized area with volcanic earthquakes in the Etna region, Italy, for Iceland, and for Greece and surroundings. The SHEEC 1900-2006 epicentres are shown in Fig. 2.

The differences between the two files for the period 1900-2006 within the SHEEC area are as follows:

Arctic Ocean After the delivery of the GFZ data to the SHARE project in April 2011, the northern border of the SHEEC study area was slightly extended above 72°N as the original northern border, i.e. even above the northern border of the EMEC study area at 73°N up to 73.5°N in a small region from 11°-17°E (see Figure 1). In this as well as in the area 70°-72°N, 5°-17°E, solutions by Bungum (pers. communication, NORSAR) supplement those provided by EMEC. In total there are 22 events from the NORSAR data file. They appear in the SHEEC 1900-2006 file with the main reference NORSAR. Almost all of these events exist also in the GFZ database, but were

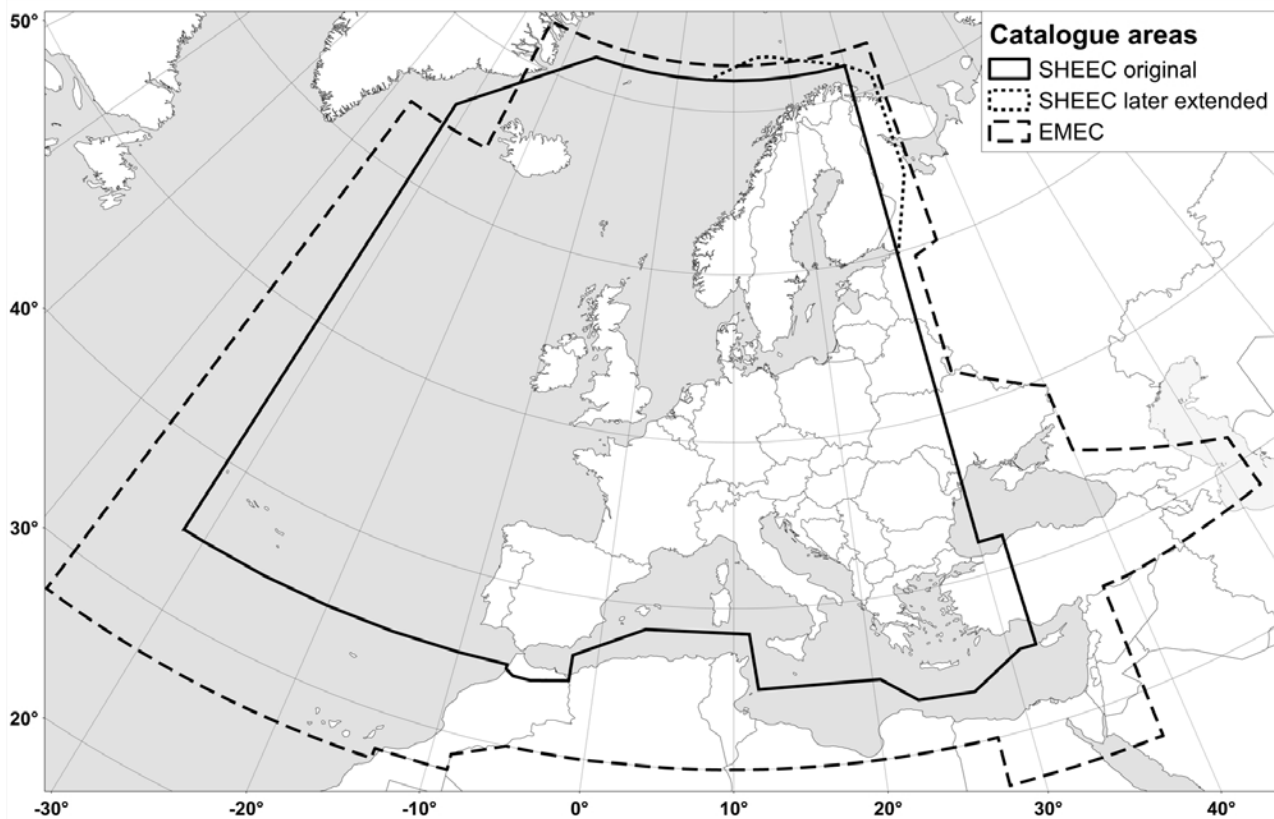


Figure 1 Comparison of the original and later extended catalogue areas for SHEEC with the study area of EMEC

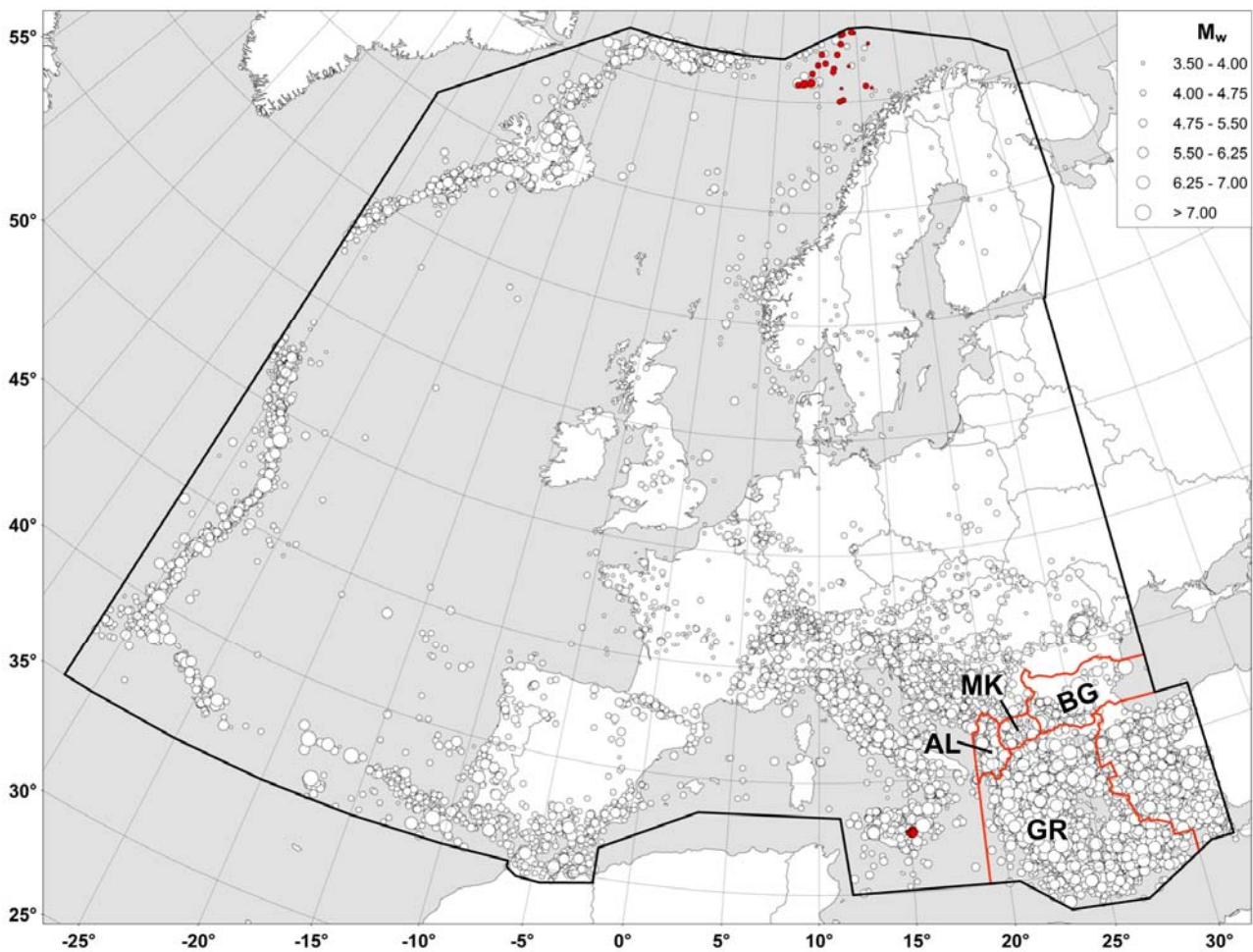


Figure 2 The epicentres of the earthquake entries of the SHARE European earthquake catalogue SHEEC for the time period 1900–2006. The epicentres of 79 earthquakes, which were added to the about 13,600 EMEC entries within the SHARE study area are displayed in red. Also marked in red are the polygons “Greece” (GR), “Albania” (AL), “Macedonia” (MK) and “Bulgaria” (BG) according to G&W12 within which the data from Papazachos et al. (2003, 2009) and Roumelioti et al. (2010, 2011) in the catalogue hierarchy of EMEC were replaced by the data from Makropoulos et al. (2012)

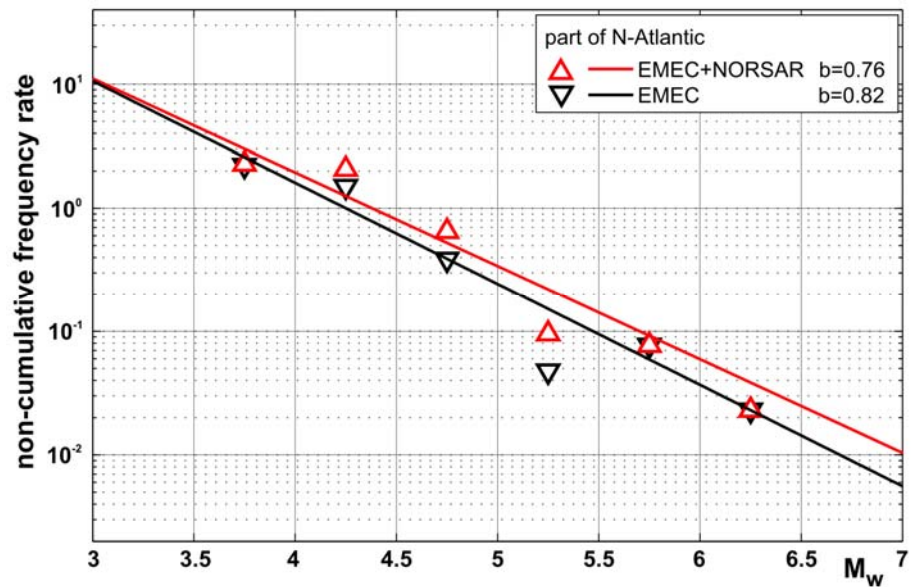
omitted in the EMEC catalogue and thus in the original SHEEC catalogue, since they do not fulfil the catalogue-polygon assignment philosophy of EMEC and/or have no useable magnitude according to our source(s), from which M_w could be calculated. The comparison of the frequency-magnitude graphs according to the EMEC data and those enriched by the NORSAR data are shown in Fig. 3 for the region, where both files overlap, i.e., from 70°–73°N and 5°–17°E for the hazard-relevant declustered data, i.e. after removing the dependent events (foreshocks and aftershocks) from the datasets. The differences are negligible in the hazard-relevant magnitude range 4.5–6.5.

Kola Peninsula and neighbouring area Simultaneously to the changes described above, the NE part of the SHEEC polygon was extended to longitudes east of 30°E (see Fig. 1). Data for this region were available from

EMEC and were provided from the NORSAR data file as well (Bungum, pers. communication). Since this area is known for fairly strong explosions, even a few nuclear ones, and rockbursts from sites of active mines and open pits, special care has to be applied in discriminating non-tectonic seismic events. Therefore, all newly provided data were carefully checked against the reliable regional bulletins of the Helsinki Institute of Seismology. In conclusion, we could use solutions for four earthquakes from the EMEC database in this extended catalogue area of SHEEC.

Iceland and surrounding waters The final EMEC data file was generated with a better harmonized improved M_w calculation algorithm for the Icelandic catalogues (IMO, 2007a, b) as described in G&W12. This modification for the final EMEC file has led to a systematic increase in M_w

Figure 3 The frequency–magnitude graphs for the Arctic Ocean (5–17° E, 70–73° N) according to the original EMEC data (black) and those with the additional data by NORSAR (red)



of about 0.7 units compared with the data delivered earlier at the due date to SHEEC and effects 1374 events. The differences in both versions are described and illustrated with a figure in G&W12.

Etna region, Italy At the final stage of SHARE and after publication of EMEC, we were informed (Stucchi, pers. communication) that volcanic earthquakes of a very local area around the Etna volcano have been left out in the CPTI Working Group (2008) catalogue, used in EMEC as the reference for the time period after 1900. In order to include these local volcanic earthquakes in SHEEC, we have used the earlier CPTI Working Group (2004) version, and so added a number of 57 volcanic earthquakes in SHEEC.

Greece and surrounding areas For Greece it was requested to use a data file from the University of Athens by K. Makropoulos for SHEEC 1900–2006. These data were not publicly available and were not employed for EMEC (G&W12), where instead data from Papazachos et al. (2003, 2009) and Roumelioti et al. (2010, 2011) were used for Greece and surroundings. Accordingly, these four sources were not employed here. The number of event entries of SHEEC 1900–2006 in this region encompasses approximately one third of the data used for EMEC. Thus, this is an area where the difference between SHEEC and EMEC is significant. The above mentioned data file by Makropoulos et al. (2012) is not only applied in the polygon “Greece” (see also Fig. 2), but also in the adjacent polygons to the north (“Albania”, “Macedonia” and “Bulgaria”). All polygons are defined in G&W12. In the latter

polygons the events from Papazachos et al. (2003, 2009) and Roumelioti et al. (2010, 2011) are used in a subordinate rank with respect to the appropriate national catalogues in EMEC. The catalogue hierarchy in these polygons is described in detail in G&W12. The coordinates of the polygons “Greece”, “Albania”, “Macedonia” and “Bulgaria” are attached as electronic supplement.

Fig. 4 shows the frequency-magnitude graphs according to both declustered data files. The differences are smaller than expected, especially for magnitudes larger than 5.5. This results from the relatively large percentage of dependent events in the EMEC data compared to the data by Makropoulos et al. (2012) for SHEEC. The dependent earthquakes are not relevant for the Poisson-based hazard calculations applied in SHARE.

The data from the University of Athens (Makropoulos et al., 2012) became publicly available under http://www.geophysics.geol.uoa.gr/catalog/appendix_mkk.txt. We respect the wish from our Athens colleagues not to display their data on the webpage described below. Instead we refer to the link mentioned above.

3 The SHEEC 1900–2006 data file

The SHEEC 1900–2006 data file, with the restriction explained above, is available at the homepage www.gfz-potsdam.de/SHEEC-1900-2006 and consists of over 13,600 event entries with $M_w \geq 3.5$ for events with latitude of epicentral location $\geq 44^\circ\text{N}$ and $M_w \geq 4.0$ for events with latitude $< 44^\circ\text{N}$. It contains the following information:

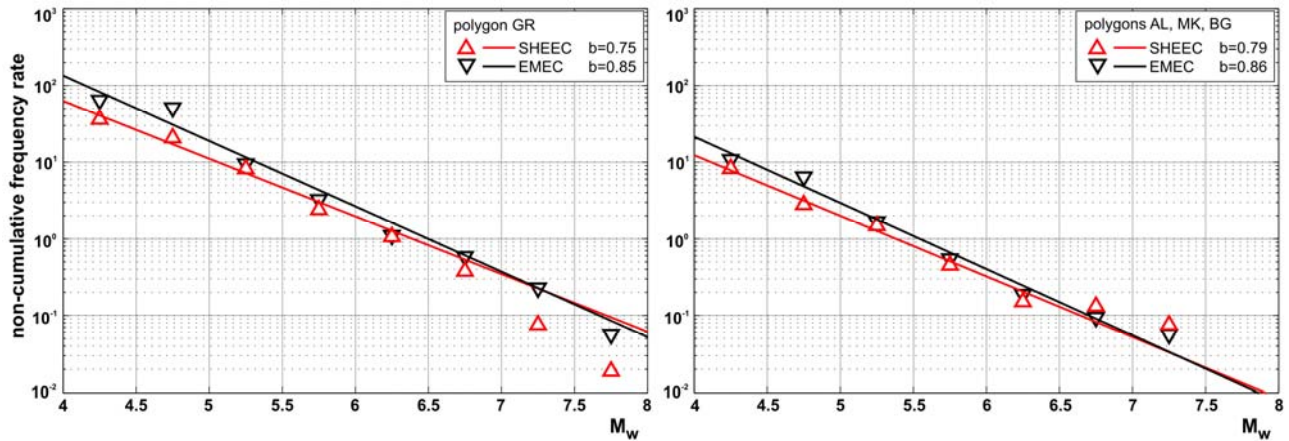


Figure 4. The frequency–magnitude graphs for the polygon “Greece” and for the three polygons “Albania”, “Macedonia” and “Bulgaria” according to the EMEC data (black) and those provided by Makropoulos et al. (2012) (red)

- Origin time. Year (y), month (mo), day (d), hour (h), minute (min), and second (s). Given are the original data without standardizing different dates (Julian or Gregorian) and different local times. However, different timings were considered in the search of duplications.
- Location. Epicentral coordinates (lat, lon) and focal depth (if available).
- Intensity I. Epicentral or (if assumed similar to epicentral) maximum intensity if given by the original source (cf. G&W12).
- Magnitude. Value and type given by an original source (M , type), and M_w value. Uncertainties in M_w have been set in the project as default values of 0.3 units before 1980 and 0.2 units later on.
- Reference. The reference of the respective sources used in EMEC (fully given in G&W12); the main reference describes the principal data source, which is inserted according to the descriptions above, i.e., basically entries from EMEC; volcanic events at Etna have the main reference CPTI04 and entries of the North Atlantic NORSAR.

4 Discussion

The SHEEC 1900–2006 data file represents, for the majority of events, an excerpt of the EMEC data file (G&W12). From the more than 13,600 earthquakes 22 new entries were added in the North Atlantic and 57 entries of volcanic earthquakes at Etna. More pronounced is the difference in the Greek and adjacent polygons, where several sources used in EMEC have been replaced by a file described in Makropoulos et al. (2012). Since the

delivery date of EMEC data to SHEEC was a few months before the submission of EMEC to publication, a late change in the EMEC file concerning M_w magnitudes for Iceland could not be considered in SHEEC 1900–2006.

After (1) applying the magnitude-dependent declustering of earthquakes, i.e., after selecting only the main shocks and (2) considering the magnitude-dependent completeness analysis, we expect that about a quarter of the entire data set is usable for probabilistic seismic hazard assessments. Induced and triggered events are not part of the file. Concerning this issue and other specifications, like unreliable focal depths, fake events, etc., see G&W12.

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