SHARE *Task 3.1*

Assessing the completeness of SHEEC, the SHARE European Earthquake Catalogue

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H. Bungum; K. Sesetyan and M. Demircioglu; D. Albarello.

Foreword

This version is basically the same as version 2, with the addition of the assessment for Eastern Turkey, which led to review the assessment of the superzone of Central Turkey.

Introduction

The assessment of the completeness of SHEEC was not addressed until the catalogue was released. Eventually, R. Musson proposed a set of superzones and applied a statistical method to their content. At the Zuerich meeting INGV-MI proposed a new set of superzones, mainly based on historical considerations; for part of them we proposed the starting year (plus or minus 50 years) of the completeness of Mw≥5.8, then we compared this values with the result of the statistical approach performed with the method by Albarello et al. (2001).
At the Oslo, SHARE General Assembly INGV-MI proposed:

a) an updated zonation, based on historical considerations;
b) the historical and statistical assessment for the completeness starting year of Mw≥5.8;
c) the historical and statistical completeness assessment for the whole Mw range for a few superzones. While for some of them the gap between the two assessments was not large, one of them showed a consistent gap among the historical and the statistical approach.

The minutes report: *"after much discussion it was decided that the completeness will be estimated using the historical approach wherever and whenever the data allow this to be done and calculated the statistical approach elsewhere in the entire SHARE region."* It was also decided that INGV-MI would deliver the preliminary estimates to Task 3.1 partners and collaborators for feedbacks.
The first version of the estimates was delivered on June 28, 2011. A dedicated web tool was established to gather comments from the partners. Comments were received from: J. Fonseca, S. Vilanova and F. Carrilho; J. Batllo; V. Kouskouna and K. Makropoulos; T. Camelbeeck; J. Woessner; R. Musson; H. Bungum; D. Albarello. The completeness estimates for the Aegean, Marmara and Western Turkey areas were revised together with K. Sesetyan and M. Demircioglu in the frame of a meeting for merging the Turkish portion of the EMME and SHEEC catalogues before 1900 up to 32° E. The received contributions led to:

i) a revised version of the completeness superzones;
ii) a revised completeness assessment in the superzones.

Following the suggestion of the Oslo minutes, the historical and expert judgement assessments were preferred; they represent the best possible result with the largest possible consensus that could be achieved in the available time frame.

Completeness and complete time-intervals

The assessment of completeness is still a kind of black hole, mainly performed according to statistical methods, which are usually driven by recent seismicity patterns and cut away important portions of the historical dataset.

The completeness assessment divides the seismicity into two portions: the complete (useful) portion and the incomplete (useless) one, which is cut off. It should be noted that the commonly used statistical methods cut about two thirds of the entire catalogue off. The assessment can be critical in the regions with low to moderate and irregular (in time) seismicity, while in regions where the seismicity is high and regular in time, or very low, it may have no big influence.

Whatever the approach, the results define the time-intervals in which the seismicity sample is supposed to be complete and, therefore, representative of the "true" seismic activity, to be used for assessing the activity rates. The assessments come in terms of a series of couples in each zone: Mw class and relevant starting year of completeness.

Methods: statistical

The current methods for assessing completeness of statistical type analyze the available data and their pattern; a review of them is included in Albarello et al. (2001). The method by Albarello et al. (2001) supplies the starting time of completeness for varied Mw bins and, in addition, uncertainty in terms of years plus or minus the starting year. It has *pros* and *cons* and, according to D. Albarello (pers. comm.) the results are to be used as preliminary hints for the historical assessment.

Methods: historical

The historical approach looks outside the data and, therefore, it can be epistemically alternative with respect to the previous one. It considers the way earthquakes have been recorded by the historical sources, how these have been preserved and investigated, etc.

It mainly applies to damaging or destructing earthquakes, starting at about Mw5.8. An overview and an approach are found in Stucchi et al. (2004). The approach requires the investigation of the main sources of information for a number of localities, devoted to understand whether the gaps of seismic evidence are due to lack of earthquakes or to lack of sources. When such investigation requires too many resources, it can be substituted by a kind of expert judgement.

The results cannot be precise at the year; therefore, the historical assessment comes with uncertainty in time (about plus or minus 50 years). In principle it should come together with an uncertainty in terms of probability; another way of accounting for the uncertainty would be to assess that the seismicity of a given Mw value is complete after, say, 1650, with the possibility that one or two events may be missing.

Superzones: why and how?

Although completeness will be used for assessing activity rates in individual AS, superzones are needed for the following reasons:

- the historical considerations apply to areas larger than AS;
- the statistical approach requires a good data sample, which is not always the case for many AS *(by the way, one may wonder if this is not an evidence of too small AS.....).*

We propose the superzones of Fig. 1, mostly based on historical considerations. The superzones derive from the grouping of individual AS.

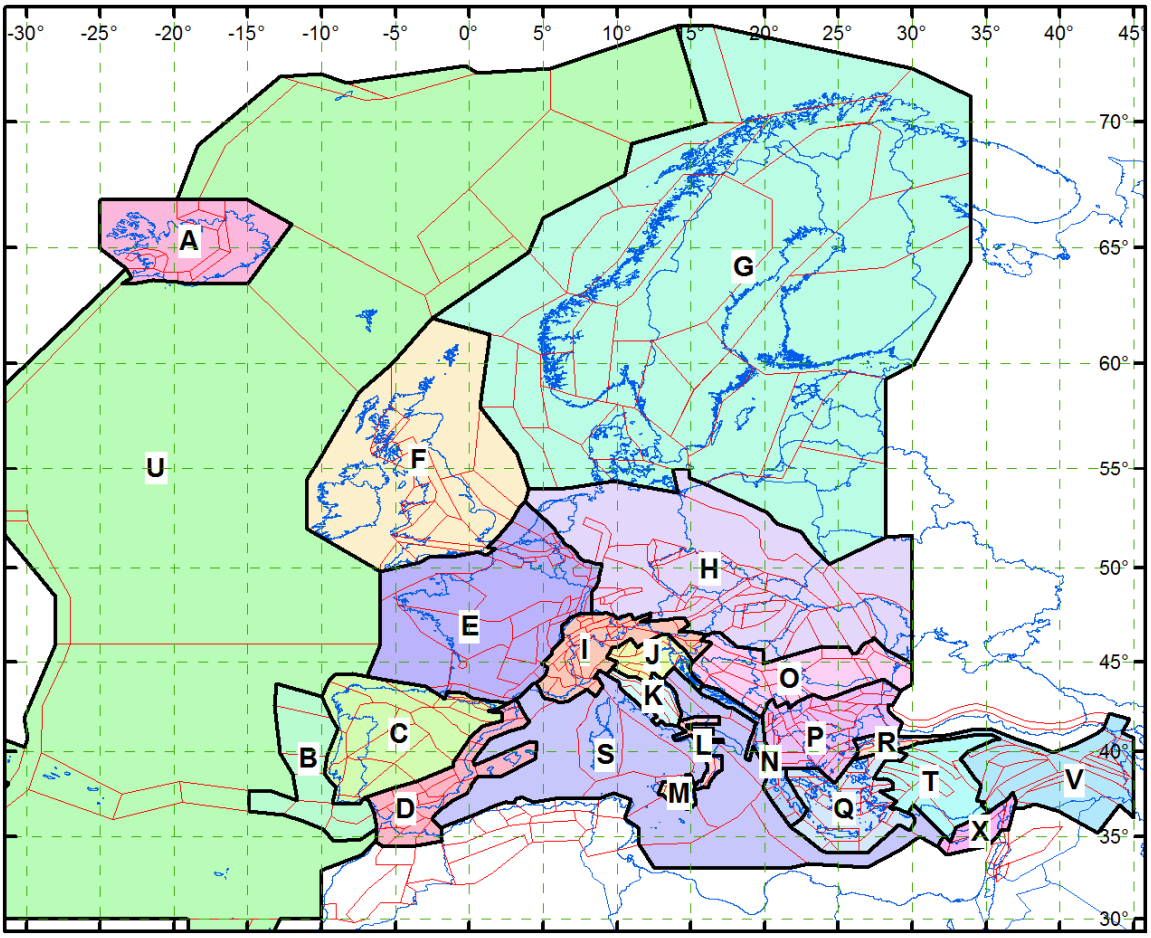


Fig.1 – Completeness superzones.

Mw 5.8 and Mw 6.8: why?

Mw5.8 (plus or minus uncertainty) is the size of crustal, partly destructive earthquakes which are usually capable of leaving durable traces in the historical accounts and sometimes in the buildings. In Europe it may cause damage around I = 8.

The historical completeness starting year for Mw ≥ 5.8 is defined as the upper bound of the time-interval in which a partly destructive event did not escape being recorded by the written sources, the same ones having been preserved and investigated.

Mw6.8 (plus or minus uncertainty) is the size of crustal, highly destructive earthquakes which may cause damage around I = 10 in Europe. The historical completeness starting year for Mw ≥ 6.8 is usually far older than the previous one.

Mw 5.8 and Mw 6.8: assessment

Fig. 2 presents the distribution of the historical completeness starting years for Mw ≥ 5.8 and Mw ≥ 6.8, including default 50 years uncertainty. For simplicity we have grouped the Mw5.8 starting years around four dates: 1350, 1500, 1650 and 1800. In Italy the assessment follows from the previously available estimates; in the other regions it follows from expert judgement, constrained by the evidence supplied by the seismic histories at the main localities.

Fig. 3 and 4 present the comparison of both values, historical and statistical, from the previous figures. It can be seen that the historical assessment is almost always more conservative than the statistical one, with a few exceptions in the case of Mw ≥ 5.8 (two of them, Alps and Northern Balkans, are surprising).

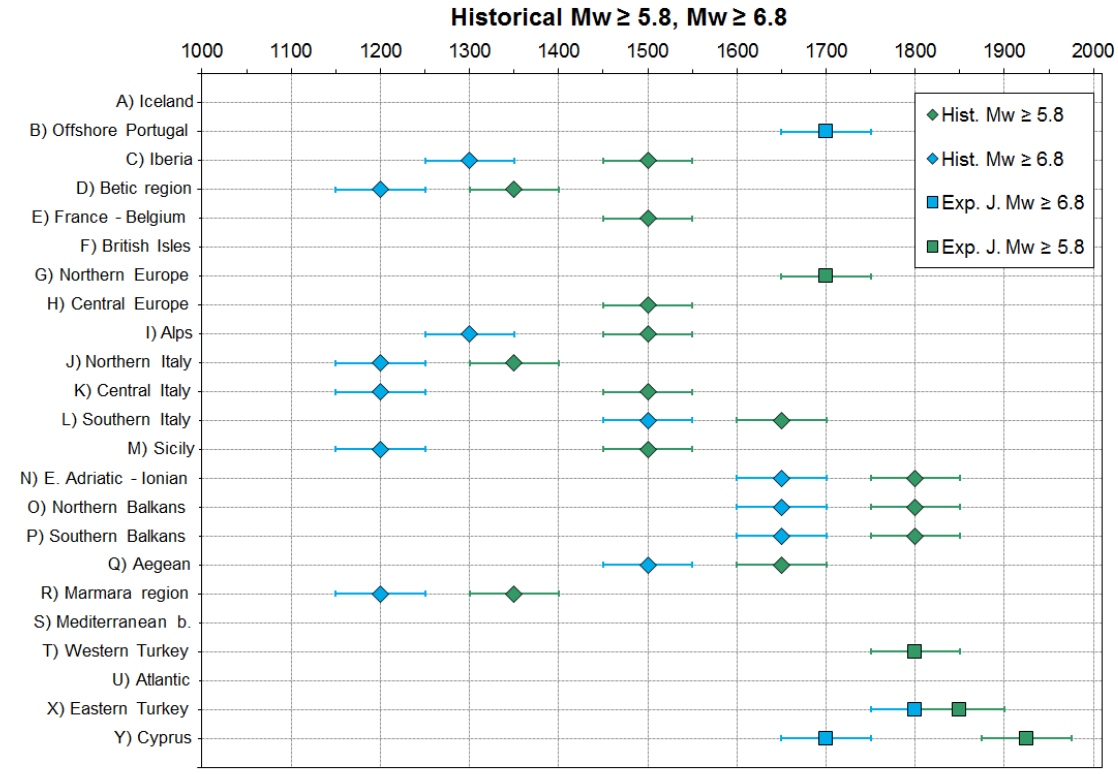


Fig. 2 – Historical completeness starting years for Mw ≥ 5.8 and Mw ≥ 6.8, including default 50 years uncertainty.

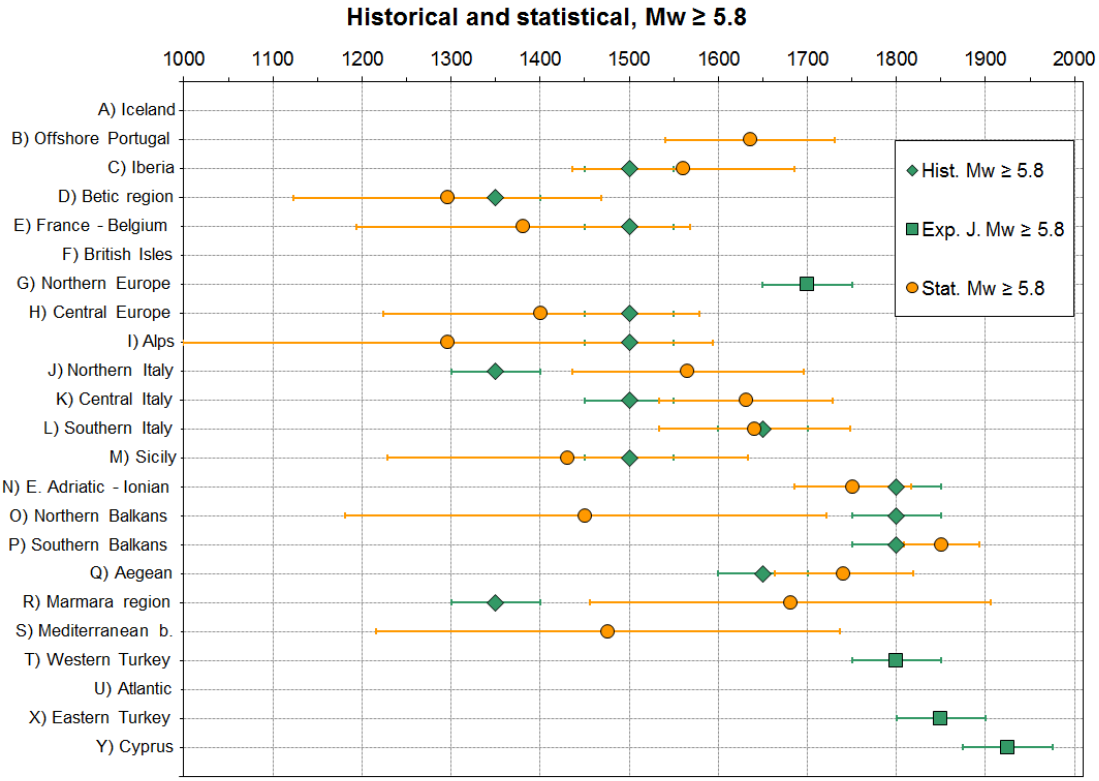


Fig. 3 – Historical and statistical completeness starting years for Mw ≥ 5.8.

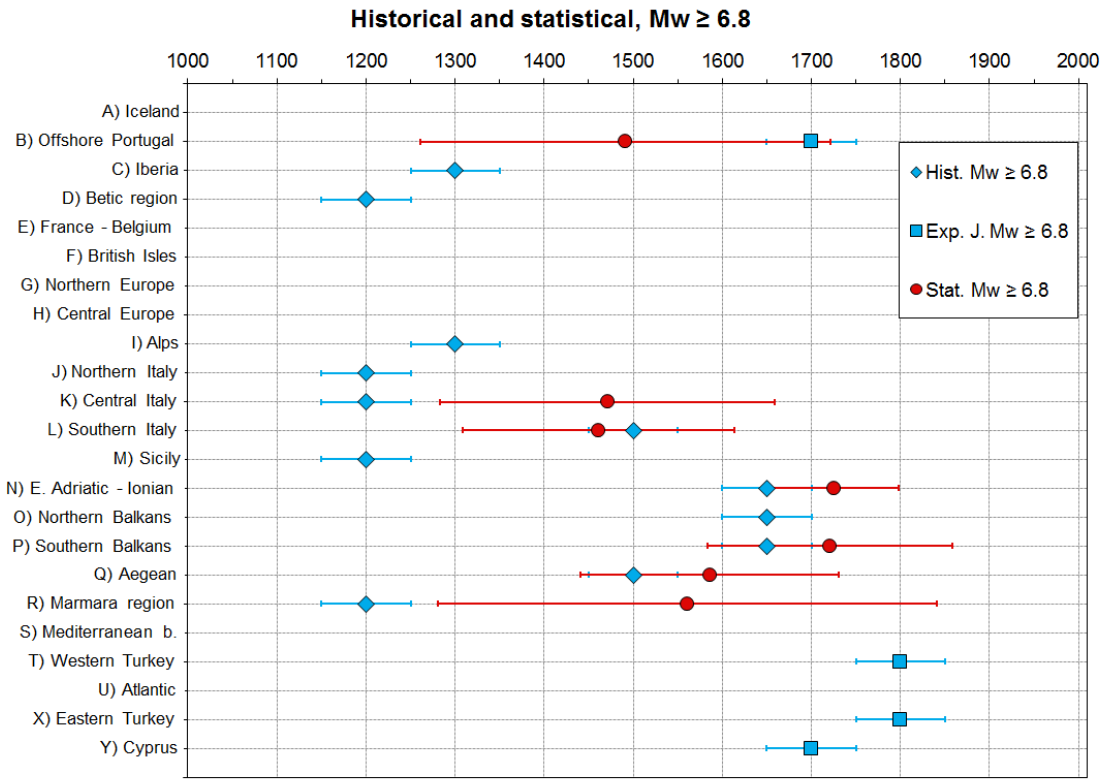
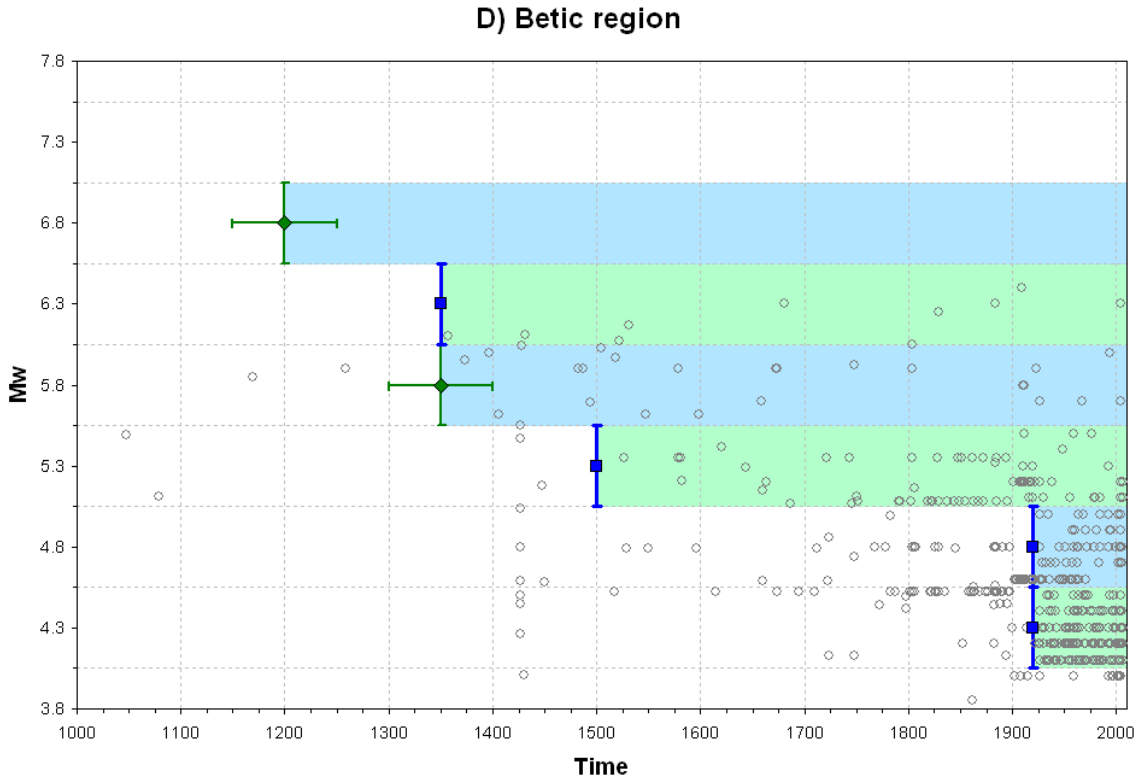


Fig. 4 – Historical and statistical completeness starting years for Mw ≥ 6.8.

Mw bins

The assessments corresponding to a given Mw value, e.g. 5.8, are meant to represent the centre of a 0.50 Mw wide bin. In other words, the completeness assessment indicated for Mw5.8 is the assessment for the Mw bin between 5.55 and 6.05. The same holds for the other Mw bins. The concept is visualized in Fig.6. The completeness of the bin corresponding to Mw3.8 has not been assessed since the relevant bin includes only half of its content. The same holds for Mw7.8 bin: we propose that the very few events which fall in that bin are included in the lower one, considering the relevant uncertainty.



Results

The proposed completeness starting years for the different Mw bins are given in Tab. 1 and presented in the Appendix. In each figure corresponding to each superzone we present:

- seismicity time distribution
- historical assessment for Mw5.8 and Mw6.8, when possible (green)
- other assessments (blue).

References

Albarello D., Camassi R., Rebez A., 2001. Detection of space and time heterogeneity in the completeness level of a seismic catalogue by a “robust” statistical approach: an application to the Italian area. Bull. Seism. Soc. Am. 91, 6, 1694-1703.

Stucchi M., Albini P., Mirto C., Rebez A., 2004. Assessing the completeness of Italian historical earthquake data. Ann. Geophys. 47, 2/3, 659-674.

Tab. 1 – Proposed completeness starting years for the different Mw classes in the superzones, corresponding to the symbols of the figures in the Appendix.

		4.3 (4.05-4.55)	4.8 (4.55-5.05)	5.3 (5.05-5.55)	5.8 (5.55-6.05)	6.3 (6.05-6.55)	6.8 (6.55-7.05)	7.3 (7.05-7.55)
A	**Iceland**	1950	1930	1930	1700	1700	1700	1700
B	**Offshore Portugal**	1950	1910	1910	1910	1910	1700	1700
C	**Iberia**	1900	1900	1800	1500	1500	1300	*1300*
D	**Betic region**	1920	1920	1500	1350	1350	1200	*1200*
E	**France - Belgium**	1900	1750	1550	1450	*1450*	*1450*	*1450*
F	**British Isles**	1900	1500	1500	1500	*1500*	*1500*	*1500*
G	**Northern Europe**	1890	1800	1800	1700	*1700*	*1700*	*1700*
H	**Central Europe**	1900	1780	1780	1500	*1500*	*1500*	*1500*
I	**Alps**	1900	1800	1800	1500	1300	1300	*1300*
J	**Northern Italy**	1880	1830	1530	1300	1300	1200	*1200*
K	**Central Italy**	1900	1830	1725	1500	1500	1200	*1200*
L	**Southern Italy**	1920	1820	1820	1650	1650	1450	1450
M	**Sicily**	1960	1700	1700	1500	1150	1150	1150
N	**East Adriatic - Ionian**	1960	1960	1900	1800	1800	1600	1600
O	**Northern Balkans**	1900	1850	1850	1850	1700	1650	*1650*
P	**Southern Balkans**	1950	1900	1900	1850	1750	1650	*1650*
Q	**Aegean**	1950	1950	1900	1650	1650	1450	1450
R	**Marmara Region**	1960	1830	1830	1300	1300	1200	1200
S	**Mediterranean background**	1960	1900	1900	1800	1800	*1800*	*1800*
T	**Western Turkey**	1960	1960	1920	1850	1800	1800	1800
U	**Atlantic**	1970	1970	1930	1930	1930	1930	1930
V	**Vrancea deep**	1970	1930	1930	1900	1750	1750	1450
X	**Eastern Turkey**	1960	1960	1925	1850	1800	1800	1800
Y	**Cyprus**	1990	1960	1925	1925	1700	1700	*1700*