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THE MIDDLE EAST EARTHQUAKE CATALOG: A SUMMARY ON WORKING PACKAGE-1; EMME: GEM PROJECT (2009-2013)

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ABSTRACT

This is a brief explanation on the efforts performed in WP1 of EMME (Earthquake Model of the Middle East), GEM (Global Earthquake Model) project during 2009-2013.This task force was a collective effort by a group of scientist from different middle east countries as well as collaboration of scientists from GEM headquarter. The new catalog using all historical (pre-1900), early and modern instrumental events up to 2006 was established. The magnitude of completeness (Mc) was determined by cumulative frequency-magnitude distribution. The value of Mc is around 5.5, 5.0, 4.5 and 4.0, for the time periods before1960, 1963, 1975 and 1995, respectively. The average of teleseismic depths in all regions is less than 20 km. Minimum depth correspond to Northern region (Alborz-Azarbayjan, Armania) with ~ 6 km. In the other subregions depths are between 10 and 16 km.

INTRODUCTION

In this article the new catalog for middle east using all historical (pre-1900), early and modern instrumental events up to 2006 was established. After omitting the duplicate events, aftershocks and foreshocks, and converting all magnitude to Mw scale, 27174 main events remain for new catalog of Middle East from 1250 B.C. through 2006 (Figure-1). Because of different seismicity which depends on geophysical, geological, tectonic and earthquake data, this region is subdivided to 9 subregions, consisting of Alborz-Azerbaijan, Afghanistan-Pakistan, Arabian Peninsula, Armania, Central-Iran, Kopeh-Dagh, Makran, Zagros and Turkey (after 30E because part of western Anatolia which is overlapped by the eastern end of European studied by SHEEC (European project of GEM)). The magnitude of completeness (Mc) was determined by cumulative frequency-magnitude distribution.

Using a complete catalog is the most important to determine seismic hazard analysis in each region. In this investigation for arranging list of earthquakes in a catalog for Middle East region; all historical and instrumental events were compiled in a new established catalog. According to Ambraseys et al. 2002, the historical record confirms that some regions that are active today (e.g., the north Anatolian fault zone) were also active 2500y ago, demonstrating the long-term nature of their seismicity. It also shows that some regions that are at present quiescent (such as the Jordan Rift Valley), are capable of generating relatively large earthquakes. For some of these events this is consistent with their known active tectonic environment.

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In the historical period, many moderate and almost all of the small events were missed out; however, after installation of WWSSN seismograms in the middle east and around the world, and by improving the seismograms in this time we have fairly good information about the earthquake events. Some catalogues covered limited time window and/or regions.

"A History of Persian Earthquakes" (Ambraseys and Melville, 1982), "The seismicity of Egypt, Arabia and the Red Sea" (Ambraseys et al., 2005) and "Earthquakes in the Mediterranean and Middle East" (Ambraseys, 2009), "The SHARE European Earthquake Catalogue (SHEEC) 1000–1899" (Stucchi et al., 2012) contain main resources of historical earthquake information on this region. Many researchers estimated some information about different features and subregions, and their specifications for each part of Middle East region. Unifying all of the records and using ZMAP software (Wiemer, 2001; Wyss et al., 2001) estimate some seismicity information for this region. In this article we describe development a new catalog of Middle East and determine some of seismicity information, i.e., number of events, range of magnitudes and magnitude completeness (Mc) and seismicity depths of this region (Figure-2).

The other major contributors of the present study were K. Sesetyan, M.B. Demircioglu, D. Kalafat, M. Erdik, D. Giardini, M. Asif Khan, N. Tsereteli. A detail of this study is appeared in Zare et al 2014.

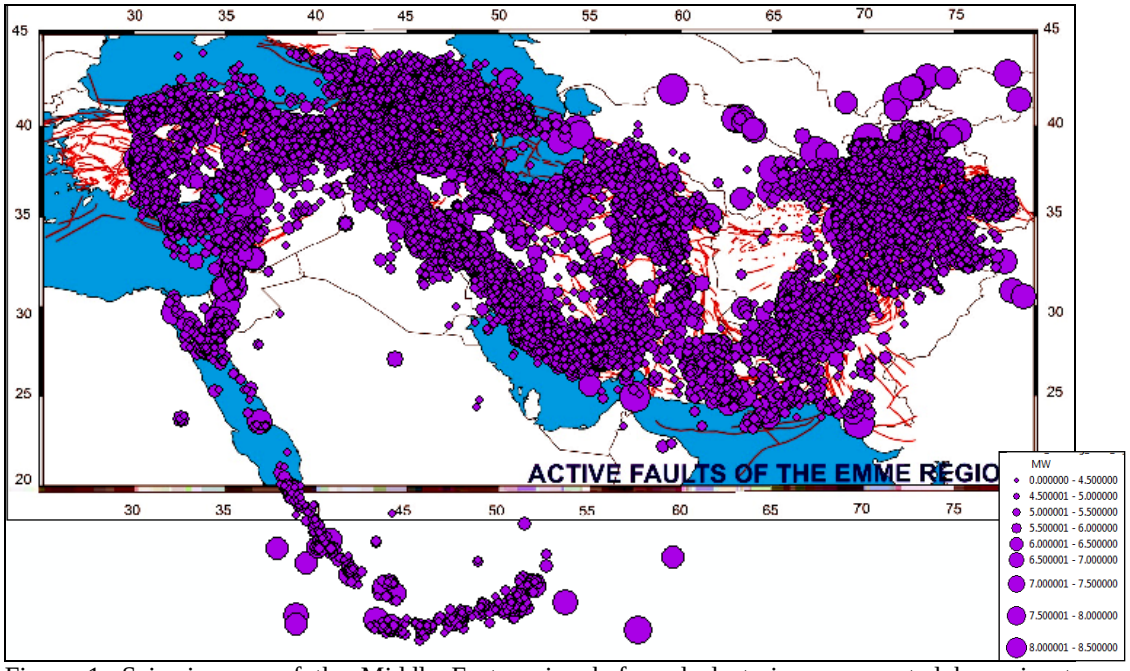

Figure 1: Seismic map of the Middle East region before declustering represented by epicenters of earthquakes occurred during historical and instrumental period.

DATABASE

In the historical period, many moderate and almost all of the small events were missed out; however, after installation of WWSSN seismograms in the middle east and around the world, and by improving the seismograms in this time we have fairly good information about the earthquake events. Some catalogues covered limited time window and/or regions. “A History of Persian Earthquakes” (Ambraseys and Melville, 1982), ”The seismicity of Egypt, Arabia and the Red Sea” (Ambraseys et al., 2005) and “Earthquakes in the Mediterranean and Middle East” (Ambraseys, 2009), “The SHARE European Earthquake Catalogue (SHEEC) 1000–1899” (Stucchi et al., 2012) contain main resources of historical earthquake information on this region.

Many researchers estimated some information about different features and subregions, and their specifications for each part of Middle East region. For Middle East region, the published studies are GPS constraints on plate motions and crustal deformation, focal mechanisms and active shortening and tectonics by Talebian and Jackson (2004) and Tatar et al (2004). Unifying all of the records and using ZMAP software (Wiemer, 2001; Wyss et al., 2001) estimate some seismicity information for this region. In this article we describe development a new catalog of Middle East and determine some of seismicity information, i.e., number of events, range of magnitudes and magnitude completeness (Mc) and seismicity depths of this region.

UNIFORM CATALOG

Ambraseys and Jackson (1998) investigated the earthquakes in Eastern Mediterranean from 464 B.C. up to 1995. For 62 of the 150 earthquakes which have both well-determined surface-wave magnitudes (Ms) from instrumentation data, and reasonably reliable rupture lengths from field observations; almost 55, 30 and 15 percent of the data came from strike-slip, normal and thrust faults, respectively. Regression between magnitude (Ms) and length of fault in kilometers (L) presented the relationship equation, $Ms= 5.13 + 1.14 \log (L)$, with a standard deviation of 0.15 in Ms. They also represented relationship between magnitude (Ms) and resultant displacement from horizontal (H) and vertical (V) in centimeters (R) by $Ms = 5.21 + 0.78 \log (R)$.

Conversion to one magnitude scale needs to prepare a unified catalog. Comparison between recorded events in mb, ML, Ms and Mw magnitude scale show that determine correlation among of these scales in our catalog’s records needs to use them for further conversions instead of any other formula from other authors.

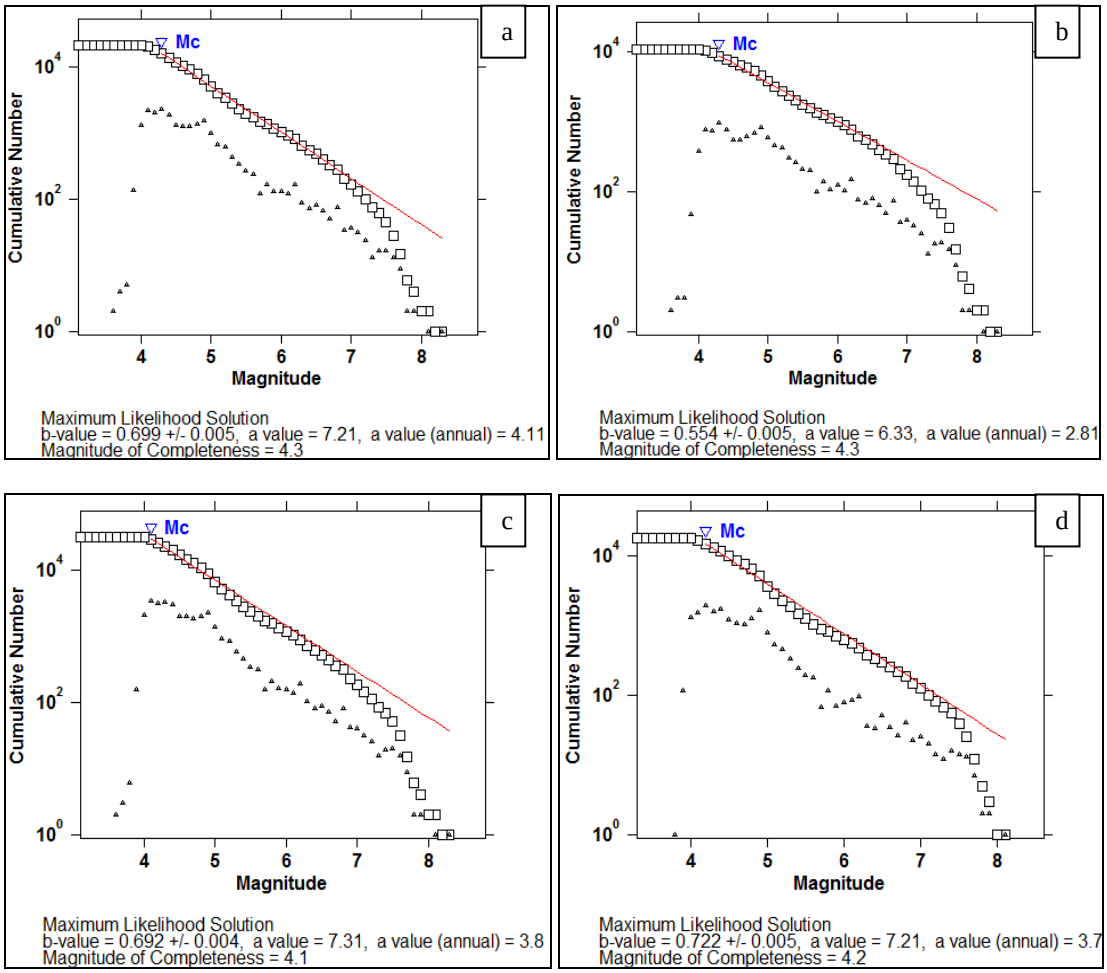

Figure 2:. Cumulative frequency number distributions plots after declustering using each of the methods; (a) Gardner and Knopoff method, (b) Gruenthal method, (c) Reseanberg method, and (d) Uhrhammer method.

Now, in this catalog, all of magnitude scales was unified by using regional conversion equations between mb, Ms, ML and Mw and convert to magnitude in Mw scale. After omit events with 0 magnitudes and erroneously large depth (Wyss et al, 2001), there will be a catalog with 28244 events from all of historical and instrumental events, in Mw magnitude scale (figure 3). This catalog contains events with magnitude 3.7-8.3 between 1250 B.C. and 2006 of which 10928 events occurred between 1976 and 2006 in last 10 years.

DECLUSTRING

Each catalog needs to omit duplicate events, aftershocks and foreshocks; on the other hand, main shocks should be separated for the final catalog. We study the most common declustering methods, mainshock-window and linked-window declustering. The Zmap Software (Weimer, 2001) was used to declustering these events. There are four algorithms for doing decluster in this software. Each algorithm considers different time and distance range for declustering. The Middle East catalog was declustered with the Gardner and Knopoff (1974), Gruenthal, Uhrhammer (1986) and Reseanberg (1985) algorithms.

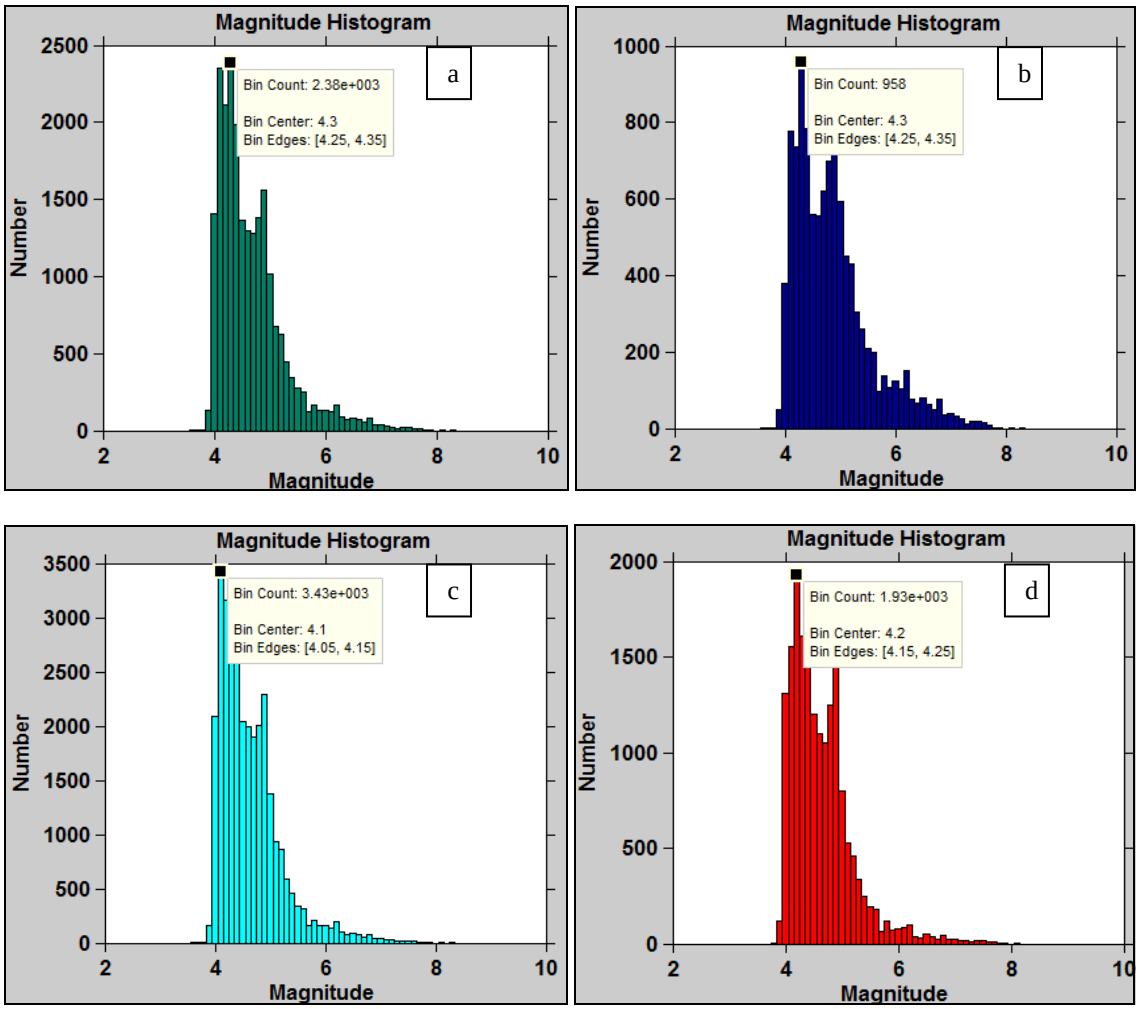

Figure 3: Calculated Frequency-magnitude distributions plots after declustering using each of the methods; (a) Gardner and Knopoff method, (b) Gruenthal method, (c) Reseanberg method, and (d) Uhrhammer method.

CONLUSION

The uniform catalog of earthquakes in Middle East has provided a reliable and most complete collection of available information for seismic study in this region. It emerges from temporal and spatial completeness study of the catalog that significant variation in data survival in historical, early instrumental and modern instrumental time periods. After unified catalog by using regional conversion equations between mb, Ms, ML and Mw and convert to magnitude in Mw scale, there was a catalog with 28244 events from all of historical and instrumental events, in Mw magnitude scale. In this primary catalog summary of earthquake origin times, longitude, latitude, magnitudes and depth for each event presented.

Wiemer's ZMAP package (2001) to apply Reasenberg's algorithm (1985) was used to omit duplicate events, aftershocks and foreshocks; finally, 27174 main events remain for this region in this catalog from 1250 B.C. through 2006. Events of this region were divided to 9 subregions consist of Turkey (after 30E), Armania, Alborz-Azerbaijan, Kopeh-Dagh, Central-Iran, Makran, Zagros, Afghanistan-Pakistan, and Arabian Peninsula.

Using some of information of this catalog gives some results in seismic hazard. Plot of events in each period of 5 years confirms that the number and accuracy of events were increased in length of time until now. There is only one event with more than 8 magnitudes in this region (1945 in Makran, magnitude of 8.1). Moreover, there are 134 events between 7 and 8, 560 records between 6 and 7,

4041 events between 5 and 6. Totally, Maximum and Minimum magnitudes in this catalog are 3.8 and 8.1 respectively.

The magnitude of completeness was determined by cumulative frequency-magnitude distribution of Gutenberg and Richter (1944) and seismological analysis in software ZMAP (Weimer, 2001) for total of Middle East and its subregions. The threshold of magnitude based on all Middle East earthquake data was calculated 5.5, 5.0, 4.5 and 4 (or less than 4) for the time periods before 1960, 1963, 1975 and 1995, respectively.

According to this investigation in Middle East region by averages of depth for each subregion are estimated by using software ZMAP (Weimer, 2001) and by plotting all of events in their depth. Average of depth for Alborz-Azarbayjan and Armania; Makran, Arabian Peninsula and Turkey (after 30˚E); Kopeh-Dogh; Central-Iran; Zagros and Afghanistan- Pakistan are approximately 6; 10; 11; 16; 14 and 12 respectively. Totally, events of earthquake occurred in depths of less than 20 in Middle East region.

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