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AN IMPROVED EARTHQUAKE CATALOGUE ($M \geq 4.0$) FOR TURKEY AND NEAR SURROUNDING (1900-2012)

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ABSTRACT

Many earthquake catalogues, agencies report and research articles have been published for Turkey and near surrounding for the last fifty years. However, most of this data are not fulfil in the required standards, for instance, some uncertainties and errors on epicentral location, magnitude heterogeneity and inaccuracy in date and time records. The lack of standards of the available catalogues reinforced the need for a refined and updated catalogue in order to support the earthquake related hazard and risk assessments.

The Disaster and Emergency Management Presidency of Turkey launched a series of systematic projects in order to reduce the future losses related earthquakes under the framework of the National Earthquake Strategy and Action Plan (UDSEP-2023). An improved earthquake catalogue has been prepared to be a database for the ongoing projects of the UDSEP-2023, which are the Seismotectonic Map of Turkey and the Seismic Hazard Map of Turkey.

The improved earthquake catalogue covers 32-45^{o} N and 23-48^{o} E coordinates and includes 12,674 events during 1900-2012. Magnitudes range from 4.0 to 7.9 concerning various types of moment magnitude (Mw), surface wave magnitude (MS), body-wave magnitude (Mb), local magnitude (Ml) and duration magnitude (Md). The maximum focal depth reaches up to 225-km. During the study, about 37,000 earthquakes and related parametric information were evaluated utilizing more than 30 published data. Then, an integrated database has been built up in order to analyse all parameters acquired from the catalogues and references for each event. Additionally, epicentral locations of $M \geq 5.0$ were reappraised benefiting from the updated Active Fault Map of Turkey prepared by the General Directorate of Mineral Research and Exploration, with high epicentral location credibility for selected earthquakes.

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INTRODUCTION

Earthquake is a natural phenomenon that mainly originates from the active faults and when it harmfully affects human and their property, it turns into a disaster. The technological development and the abundance of the present seismic networks ensure more accurate earthquake related parameters and their accuracies. Since the beginning of seismology till today, earthquake related information have been documented and archived. Thus, many records, catalogues and documents have been brought from early periods to present.

Disaster and Emergency Management Presidency, Earthquake Department (AFAD) and Kandilli Observatory and Earthquake Research Institution (KRDAE) have been operating seismic networks throughout Turkish mainland. They periodically publish data on catalogues and bulletins for institutions, organizations and public.

Some earthquake catalogues prepared by institute or researchers provided considerable amount of data for Turkey and near surrounding for the last fifty years. Major catalogues that include reliable epicentral coordinates can be listed as; Gutenberg and Richter (1954), Alsan et al. (1975), Ayhan et al. (1981), Ambraseys and Finkel (1987), Ambraseys and Jackson (1998), Kalafat et al. (2011), National Earthquake Information Centre (NEIC) Catalogue, Bulletins of International Seismological Summary (ISS), International Seismological Centre Event (ISC) Catalogue, Engdahl, 1998 van der Hilst and Buland (EHB), European-Mediterranean Seismological Centre Earthquake Catalogue (EMSC-CSEM), The Harvard Centroid Moment Tensor Catalogue (HRVD) and Disaster and Emergency Management Presidency of Turkey (AFAD) Catalogue. Beside these, there are many national and international subsidiary catalogues or research papers (Storchak et al. 2012, Karnik, 1968; AS, ATH, BCIS, CGS, DUSS, EIDC, GBZT, GRAL, HFS, HFS1, IASPEI, ISN, JER, JSO, KRDEA, LAO, LDG, MOS, NAO, NEIS, NIC, SOF, THE, THR, UNS, USGS, USCGS,)

The EMSC-CSEM and the ISS-ISC constantly compile data from the contributor agencies that provide wide database. However, the ISC and the EMSC catalogues usually do not include events between 1900 and 1950. The ISC catalogue has been determining epicentral locations by means of the an automatic algorithm since1964, but the EMSC has been started since 1998. Nevertheless, some studies (Ambraseys and Finkel, 1987; Gutenberg and Richter, 1954; Ayhan et al. 1981; Alsan et al. 1975 comprise events for earlier period, from 1900 to 1950. Whereas MS magnitude is prevalent before the mid of 1970s, magnitude types become vary after the late of 1970s moment magnitude (Mw), surface-wave magnitude (Ms), body-wave magnitude (Mb), local magnitude (Ml) and duration magnitude (Md) in the catalogues. For the Mw, Harvard Moment Tensor Catalogue (GCMT) is widely accepted by the seismology community.

In order to reduce the earthquake related losses and damages in Turkey, AFAD launched a series of systematic projects regarding the new approaches under the framework of the National Earthquake Strategy and Action Plan (UDSEP-2023). One of these projects is the Seismotectonic Maps of Turkey, which includes also reappraising available earthquake catalogues.

For understanding earthquake activities, first step is to prepare the earthquake catalogue. The available catalogues have some deficiencies, which are necessary for the earthquake related hazard and risk studies. For example, magnitude heterogeneity, some uncertainties and errors on epicentral location, date and time records are the main problems. These ambiguities reinforced the need for the improved and updated catalogue to support the earthquake related hazard and risk assessments.

INTEGRATED DATABASE

The new, improved catalogue covers of earthquakes from 1900 to 2012 in an area which extends between 32-45^o N and 23-48^o E, shown in Figure 1. The catalogue has been prepared in the light of previous data consisting of catalogues, agencies reports and research articles. During the study, about 37,000 earthquakes and related parametric information were evaluated utilizing a total of

41 of the 12 main sources between 1900 and 2012. Then, an integrated database has been built in order to analyse all parameters acquired from the available data for each event. The full database was queried with both cross correlation and spatial comparison. Detailed examination of the database revealed that the available catalogues and references have some uncertainties and errors on the parametric information. The main problems arise from the full database are on epicentral location, magnitude heterogeneity and inaccuracy in date and time records. Some features and uncertainties at the previous data are highlighted in Table 1. An example for the integrated database showing the parametric information acquired from the selected sources given in Table 2.

More reliable and relatively uniform information have been extracted from the integrated database to form final catalogue. In the final database, all selected sources were indicated respectively and parametric information was incorporated. In the chronologic order, Figure 2 shows the selected references and catalogues for the final database.

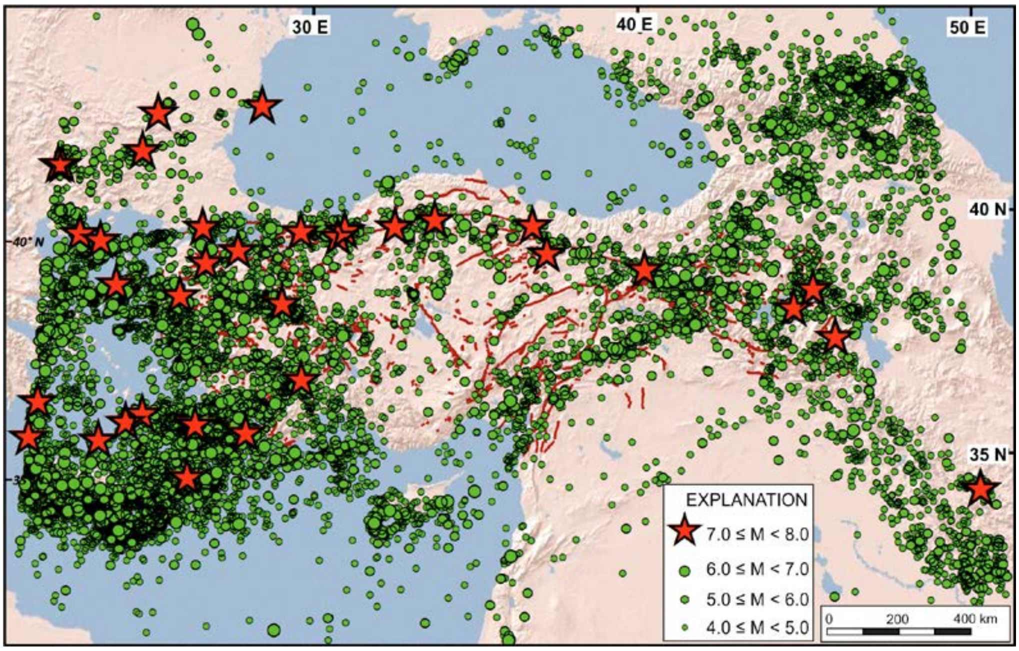

Figure1. Distributions of the epicentral locations of (4.0≤ M< 8.0) in the improved catalogue

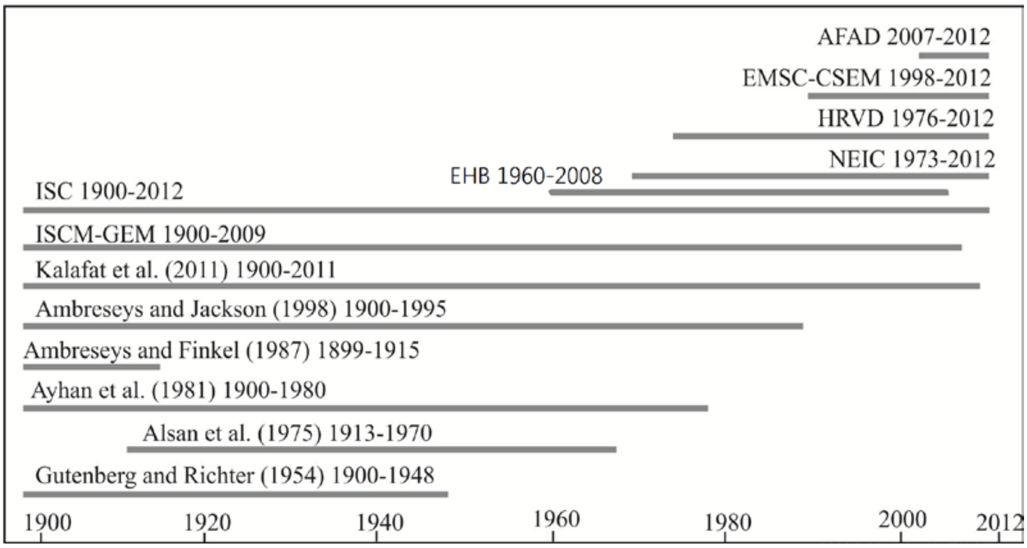

Figure2. Main sources used for the integrated database, in the chronologic order.

Table 1. Some features and uncertainties at catalogues and references

Catalogues	Some features and uncertainties
Ambraseys, and Finkel, (1987) Period covered:1900-1915	Inaccuracy in date-time and focal depth information for some events. They have made it a priority to rely as much as possible on primary sources in which the macro seismic and instrumental data are treated in their regional context.
Alsan, et al. (1975) Period covered: 1913-1970	For the interval 1913-1970, source parameters have been calculated on computer, as far as available data permits. For the focal depth, the errors can generally be given as ± 5 km for $h \leq 80$ km and ± 10 km for $h > 80$ km.
Ayhan, et al. (1981) Period covered: 1881-1980	The catalogue contains $Ms \geq 4.5$, inaccuracy in focal depth information for certain events. It was accepted as *D2* for the earthquakes which have no focal depth information.
Gutenberg and Richter, (1949; 1954) Period covered: 1900-1948	The main purpose of this catalogue is; to evaluate the present relative seismicity of various parts of the earth, and to discuss the geography and the geological character of the zones and areas of seismic activity
Ambraseys and Jackson, (1998) Period covered: Pre 1900 to 1995	This catalogue based on surface faulting data related to large earthquakes.
Kalafat, et al.(2011) Period covered: 1900-2010	The Catalogue contains $M \geq 4.0$ earthquakes between 1900 and 2010. There is some missing event especially for the period 1900-1915. For each event according to constant reference magnitude type, other types have been derived.
ISC Catalogue Period covered: 1960 to present	Widely comprehensive catalogue, An automatic algorithm decides which events in the ISC database merit a review by the ISC Analysts. The decision is based on M, which is the maximum of all network magnitudes reported for a given seismic event [1]. Catalogue contains Gutenberg and Richter (1954) data for the interval 1900-1948. For the some events there is more than one information belongs to same reference
EHB Catalogue Period covered: 1960-2008	The EHB is a groomed version of the ISC Bulletin, and contains data for 141478 events from 1960 to 2008. The Engdahl et al. (1998; EHB) algorithm has been used to significantly improve routine hypocenter determinations made by the ISS, ISC and PDE before a new ISC location algorithm (Bondár and Storchak, 2011) was introduced for data year, 2009 [2]
EMSC Catalogue Period covered: 1998 to present	EMSC have collected data from nearly 130 different agencies, and performed re-location. Therefore the data has high location credibility. Two types of data are presented as a catalogue and a bulletin. Bulletin data is complete for the period 1998-2011 and catalogue data is available for after 2011.
NEIC Catalogue Period covered: 1973 to present	The mission of the National Earthquake Information Centre (NEIC) is to determine rapidly the location and size of all destructive earthquakes worldwide and to immediately disseminate this information to concerned national and international agencies, scientists, and the general public. The NEIC compiles and maintains an extensive, global seismic database on earthquake parameters and their effects that serves as a solid foundation for basic and applied earth science research [3].
HARVARD Moment Tensor Catalogue Period covered: 1976 to present	Systematic determination, with a three-to-four-month delay, of moment tensors for earthquakes with $M>5$ globally, and accumulation of the results in the CMT catalogue. Rapid determination of moment tensors for earthquakes with $M>5.5$ globally and quick dissemination of results (“quick CMTs”). Curation of the CMT catalogue, which contains more than 25,000 moment tensors for earthquakes since 1976. Development and implementation of improved methods for the quantification of earthquake source characteristics on a global scale [4]. Harvard Moment Tensor Catalogue (GCMT) has been used basically in the final catalogue.
AFAD, Earthquake Department Catalogue Period covered: 2007 to present	AFAD Earthquake Department, telemetric network was established in 1989 with 12 stations. Since then, AFAD Catalogue includes data from its own telemetric network. But thanks to the “Development of National Seismological Observation Network Project” the number of stations has been dramatically increased and especially after 2007 the data has become more reliable. Therefore AFAD Catalogue is used for the interval 2007-2012.

Table 2. An example of integrated database for an event (Abbreviations: Ref, Reference; Mo, Month; Yr, Year; Mn, Minute; Sec, Second; Lat, Latitude; Lon, Longitude; Dp, Depth)

Ref.	Day	Mo.	Yr.	Hr.	Mn.	Sec.	Lat. N	Lon. E	Dp. (km)	M	Ms	Mb	Md	Ml	Mw
Kalafat et al. (2011)	28	12	2008	22	58	58.30	40.4100	25.8100	9	-	5.2	5.1	5.0	5.2	5.2
EMSC	28	12	2008	22	58	59.00	40.3700	25.7900	10	-	4.4	5.1	-	-	5.1
ISC	28	12	2008	22	58	59.49	40.3781	25.7925	8	-	4.8	4.9	-	-	-
THE	-	-	-	-	-	-	-	-	-	-	-	-	-	5.1	-
BEO	-	-	-	-	-	-	-	-	-	-	-	-	-	5.6	-
BJI	-	-	-	-	-	-	-	-	-	-	5.1	5.0	-	-	-
IDC	-	-	-	-	-	-	-	-	-	-	4.6	4.4	-	4.2	-
ISCJB	-	-	-	-	-	-	-	-	-	-	4.8	4.9	-	-	-
PDG	-	-	-	-	-	-	-	-	-	-	-	-	4.8	4.7	-
ATH	-	-	-	-	-	-	-	-	-	-	-	-	-	4.8	-
USGS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.0
MOS	-	-	-	-	-	-	-	-	-	-	4.7	5.1	-	--	-
DDA	28	12	2008	22	59	01.00	40.3300	26.0000	2.9	-	-	-	-	5.1	-
NEIC	28	12	2008	22	58	59.00	40.3900	25.7800	35	-	-	-	-	-	5.2
HRVD	28	12	2008	22	59	02.00	40.3900	25.7800	35	-	-	-	-	-	5.2

EPICENTRAL LOCATIONS, MAGNITUDES AND FOCAL DEPTHS

Spatial comparison of the epicentral positions by CIS revealed that the same earthquake is located in different coordinates. Various sources proposed dissimilar types of magnitude such as the MS, Mb, Ml, Mw and Md. Moreover, focal depth has always been an individual problem outside sufficient local networks of seismic stations. The challenge is to determine refined parametric information, especially epicentral locations, magnitudes and focal depth from various sources. In preparation of the new catalogue, the EMSC-CSEM and the ISS-ISC catalogues are principally preferred.

For the epicentral location, the AFAD, ISC, EHB, EMSC and Kalafat et al. (2011) catalogues were primarily assessed. If available, the AFAD and Kalafat et al. (2011) catalogues were favoured, after the early 1980s, since they have inadequate seismic network in Turkish mainland. For the earthquakes which occurred in marine area and neighbouring countries land, after the early 1950s, primarily the ISC and the EMSC catalogues were evaluated, which implement relocation by collecting vast amount of data from the contributor agencies. Before the early 1950s, epicentral location suggested by Ambraseys and Finkel (1987), Gutenberg and Richter (1954), Ayhan et al. (1981) and Alsan et al. (1975) are primarily preferred.

Each epicentral location of the earthquake with magnitude ≥ 5.0 is analysed together with the updated Active Fault Map of Turkey (Emre et al. 2013) by means of GIS, for the first time in this study. The fault characters such as normal, reverse and strike slip are considered, as well as the potential maximum magnitude which could be produced by the relevant fault, evaluating the relationship between active faults and selected earthquakes. Spatial distribution of aftershocks has been also regarded. Especially in Turkish mainland, the catalogue (Ambraseys and Jackson, 1998) that was prepared with respect to the surface rupture is preferred for locations of earthquakes of $M > 7.0$

Various magnitude types such as the MS, Mb, Ml, Mw and Md were proposed by different catalogues. All the magnitude types ranging from 4.0 to 7.9 are taken into consideration. In order to provide uniformity for the improved catalogue, magnitudes were principally selected from the original sources. All magnitude types are selected from the original sources, they were not derived. Another characteristic of the catalogue is original location-original magnitude relationship, whichever source for the epicentral locations, the same source used for the magnitudes. However, some exceptions were also occurred using the ISC catalogue. For instance, if the earthquake is located within the Greece land, the priority is given to data obtained from Greece Seismological Centre (ATH or THE). Similarly, for the earthquakes located within the Iran land, the data given by Iran Seismological Centre (THR) is mainly used. In the final catalogue, only a kind of magnitude is preferred for each event for the certain period as follows;

- MS Magnitude for the interval of 1900-1976, as far as possible
- The moment Magnitude (Mw) after 1976, as a priority and other magnitude types such as Mb, Ml and Md (except original location - original magnitude relationship).

For the selection of the Mw type, the Harvard (GCMT) catalogue and the ISC-GEM catalogue were primarily compared. If there are no remarkable differences between them, the GCMT catalogue that is accepted for the whole seismology community, was used. Depths are taken from original source together with other parameters. The maximum focal depth reaches up to 225-km in the catalogue. Since the catalogue will be used as a database for Turkey Seismic Hazard Map Project, the events with focal depth up to 1-km and lacking of depth value are considered as of 10-km.

COMPARISON OF EPICENTRAL LOCATIONS WITH ACTIVE FAULTS

The epicentral location of the integrated catalogue covering the whole Turkish mainland and surrounding is plotted in Figure 1. This figure clearly shows the most of the seismically active parts of the region, which follow major active structures of the North Anatolian Fault (NAF), East Anatolian Fault (EAF), Gediz-Menderes graben systems and Hellenic-Cyprus Arc. Large earthquakes also accompanied in almost all mentioned active structures during catalogue period. The seismic activity in the region is not restricted along the major tectonic elements; it extends over this active zones. However, the activity is not clearly seen along the Dead Sea Fault system which is contentions of the EAF zone. This may be explained due to the period of the catalogue. Earthquakes in the new catalogue were correlated with the source active faults for providing the most accurate epicentral location. However, this correlation could only be achieved within Turkish mainland because of reliable active fault maps.

There is no uncertainty in defining the source fault of the major earthquakes caused surface rupture. Surface rupture is one of the more reliable parameters to determine of the historical earthquake epicentre. This parameter is utilised to correlate location of the large earthquake which formed surface rupture during the catalogue period. For instance, position of the 1944 Gerede earthquake of Mw 7.4 suggested by different catalogues are far away from the surface rupture formed by strike-slip mechanism. For epicentral location of the 1944 event, the reference prosed adjacent to the surface rupture has been selected (Figure 3).

However, moderate and small earthquakes do not form surface rupture. Therefore other seismological data utilized for the source of the moderate earthquake. Aftershock distribution arising from the single fault segment can be valuable for the source of both large and moderate earthquake. In the meantime, aftershock distribution in the non-homogeneous regions containing many active faults is not considered reliable for moderate events. The source identification for the moderate and small earthquakes having no earthquake swarm or series is the less reliable of all these. Additionally, small earthquakes observed in the region where there are no active faults, can be originated from the blind fault which does not reach to the surface. In this case, source fault description could not be made for such events. The marks obtained from correlation are as follows;

- Earthquakes of $M \geq 6.0$ can be correlated with the source active faults
- earthquakes of $5.0 \leq M < 6.0$ in homogeneous region or a single fault zone may be correlated with the source faults
- For the earthquakes of $M < 5.0$ within non-homogeneous regions containing many active faults is difficult to correlate directly to the source faults. If aftershocks, earthquake swarm or series are available, they could be correlated to source faults.

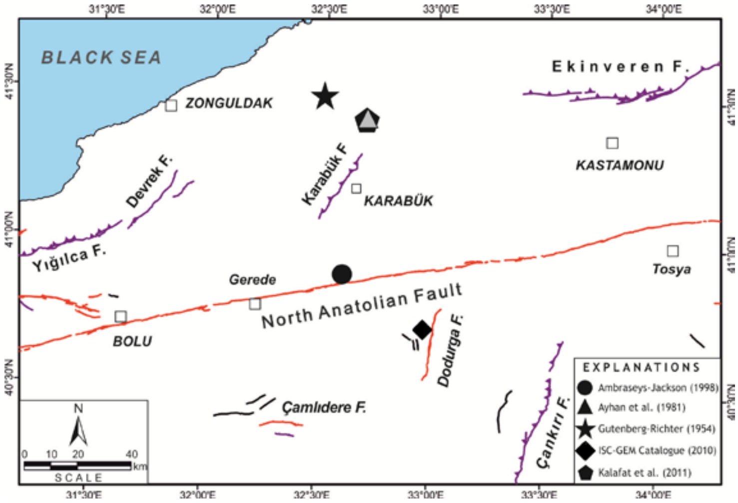

Figure 3. Different epicentral locations suggested by various catalogues or agencies for the 1944 Gerede Earthquake of Mw 7.4. Active faults are from Emre et al. 2013. (Abbreviation: F, Fault)

IMPROVED CATALOGUE

Between 1900 and 2012, the improved earthquake catalogue consists of 12,674 events as three parts. The first part includes 203 events of $M \geq 6.0$. The second part consists of earthquakes of $4.0 \leq M < 5.0$; a total 1,468 events. The third part of the catalogue composed of a much larger number of earthquakes of $M < 4.0$, bringing up the total 11,003 events. The second and third part of the catalogue is too long to be appended to this paper and it will be presented with the Seismotectonic Map of Turkey involved the UDSEP-2023. Here a parametric catalogue of only 203 earthquakes of $M \geq 6.0$ is given in Table 3.

Table 3. List of earthquakes of $M \geq 6.0$. Focal depth between 0 and 1-km are assumed as 10-km. (Letters mark: a, AFAD; b, Alsan et al. 1975; c, Ambraseys and Finkel, 1987; d, Ambraseys and Jackson 1998; e, Ayhan et al., 1981; f, EMSC-CSEM; g, Gutenberg and Richter, 1949; h, HRVD GCMT; i, ISC; j, Kalafat et al., 2011; k, EHB).

Id No	Date	Time	Latitude	Longitude	Depth	Reference	Type	Magnitude	Reference
1	31.03.1901	07:10:24	43.4000	28.7000	14	e	MS	7.2	e
2	30.07.1901	03:30:00	43.4000	28.7000	15	e	MS	6.0	e
3	08.11.1901	10:18:00	40.0300	41.5300	10	c	MS	6.1	c
4	05.07.1902	14:56:30	40.8000	23.2000	11	e	MS	6.6	e
5	28.04.1903	23:46:00	39.1000	42.5000	30	e	MS	6.3	e
6	11.08.1903	04:32:54	36.0000	23.0000	80	e	MS	7.9	e
7	13.09.1903	08:02:41	44.8000	26.7000	50	e	MS	6.2	e
8	04.04.1904	10:02:34	41.8000	23.0000	15	e	MS	7.1	e
9	04.04.1904	10:25:55	41.8000	23.1000	18	e	MS	7.8	e
10	11.08.1904	06:08:00	37.7000	26.9000	6	e	MS	6.2	e
11	10.10.1904	17:40:00	37.7000	26.8000	10	c	MS	6.0	c
12	20.01.1905	02:32:30	39.6000	23.0000	30	e	MS	6.0	e
13	30.04.1905	16:01:00	38.8100	28.5200	10	c	MS	6.1	c
14	08.10.1905	07:27:30	41.8000	23.1000	19	e	MS	6.4	e
15	21.10.1905	11:01:26	43.3000	41.7000	35	e	MS	6.4	e
16	08.11.1905	22:06:00	40.3000	24.4000	14	e	MS	7.4	e
17	04.12.1905	07:04:00	38.1200	38.6300	10	c	MS	6.8	c
18	28.09.1906	05:50:00	40.5000	42.7000	30	e	MS	6.2	e
19	28.12.1906	--- --- ---	40.5000	42.0000	30	e	MS	6.0	e
20	17.05.1908	12:30:42	35.5000	24.0000	80	e	MS	6.7	e
21	28.09.1908	06:27:00	38.3500	39.1500	10	c	MS	6.1	c
22	19.01.1909	04:57:00	38.0000	26.5000	60	e	MS	6.0	e

Tablo 3. Continued

Id No	Date	Time	Latitude	Longitude	Depth	Reference	Type	Magnitude	Reference
23	09.02.1909	11:24:00	40.2000	37.8000	10	d	MS	6.4	d
24	18.02.1910	05:09:18	35.7000	24.0000	90	e	MS	6.8	e
25	25.06.1910	19:26:00	40.8800	34.5600	10	c	MS	6.1	c
26	21.08.1910	17:14:30	34.4000	27.0000	60	e	MS	6.0	e
27	04.04.1911	15:43:54	36.5000	25.5000	140	e	MS	7.1	e
28	30.04.1911	20:42:30	36.0000	30.0000	180	e	MS	6.1	e
29	22.10.1911	22:32:00	39.5000	23.0000	15	e	MS	6.0	e
30	09.08.1912	01:29:00	40.7500	27.2000	10	c	MS	7.4	c
31	10.08.1912	09:22:00	40.7500	27.2000	10	c	MS	6.2	c
32	13.09.1912	23:32:00	40.7000	27.0000	10	c	MS	6.2	c
33	20.04.1913	03:13:47	41.9100	44.3200	10	e	MS	6.1	e
34	14.06.1913	09:33:13	43.1000	25.7000	15	e	MS	7.0	e
35	30.09.1913	07:33:36	35.0000	24.0000	60	e	MS	6.1	e
36	03.10.1914	22:06:00	37.6000	30.1000	10	d	MS	7.0	d
37	17.10.1914	06:22:32	38.2000	23.5000	8	e	MS	6.0	e
38	24.01.1916	06:55:15	40.2700	36.8300	10	b	MS	7.1	b
39	20.08.1917	23:02:09	40.3000	25.4300	40	b	MS	6.0	b
40	16.07.1918	20:03:44	36.0800	26.9900	70	b	MS	6.1	b
41	29.09.1918	12:07:05	35.2000	34.7000	10	e	MS	6.5	e
42	18.11.1919	21:54:50	39.2600	26.7100	10	b	MS	7.0	b
43	20.02.1920	11:44:25	42.0000	44.1000	11	e	MS	6.2	e
44	11.08.1922	08:19:41	35.3600	27.7000	10	b	MS	6.5	b
45	13.08.1922	00:09:53	35.5100	27.9800	10	b	MS	6.9	b
46	01.08.1923	08:16:38	35.0000	25.0000	90	e	MS	6.8	e
47	05.12.1923	20:56:35	40.0000	23.3000	15	e	MS	6.3	e
48	13.09.1924	14:34:14	39.9600	41.9400	10	b	MS	6.8	b
49	09.01.1925	17:38:34	41.3300	43.4100	60	b	MS	6.0	b
50	01.03.1926	20:02:00	37.0300	29.4300	50	b	MS	6.1	b
51	18.03.1926	14:06:14	35.8400	29.5000	10	e	MS	6.8	e
52	26.06.1926	19:46:38	36.5400	27.3300	100	e	MS	7.7	e
53	30.08.1926	11:38:04	36.7600	23.1600	26	e	MS	7.0	e
54	22.10.1926	19:59:37	40.9400	43.8800	10	b	MS	6.0	b
55	26.06.1927	11:20:45	44.4000	34.4000	27	e	MS	6.0	e
56	11.07.1927	13:04:07	32.0000	35.5000	10	e	MS	6.2	e
57	11.09.1927	22:15:48	44.3000	34.3000	17	e	MS	6.8	e
58	12.09.1927	03:20:03	44.5000	34.5000	35	e	MS	6.0	e
59	31.03.1928	00:29:47	38.0000	27.0000	35	g	MS	6.2	g
60	14.04.1928	09:00:01	42.2000	25.3000	9	e	MS	6.8	e
61	18.04.1928	19:22:51	42.2700	25.3500	7	e	MS	7.1	e
62	22.04.1928	20:13:56	38.0800	23.1200	8	e	MS	6.2	e
63	02.05.1928	21:54:32	39.6400	29.1400	10	e	MS	6.1	e
64	18.05.1929	06:37:54	40.2000	37.9000	10	b	MS	6.1	b
65	14.02.1930	18:38:19	35.9600	24.7100	91	e	MS	6.2	e
66	23.02.1930	18:19:12	39.5000	23.0000	14	e	MS	6.0	e
67	31.03.1930	12:33:51	39.7000	23.3400	10	e	MS	6.1	e
68	06.05.1930	22:34:32	37.9800	44.4800	70	b	MS	7.6	b
69	08.05.1930	15:35:27	37.9700	45.0000	30	b	MS	6.3	b
70	27.04.1931	16:50:45	39.2000	46.0000	22	e	MS	6.3	e
71	26.09.1932	19:20:43	40.3900	23.8100	5	e	MS	7.1	e
72	29.09.1932	03:57:24	40.8300	23.4600	25	e	MS	6.4	e
73	23.04.1933	05:57:37	36.7700	27.2900	30	e	MS	6.4	e
74	11.05.1933	19:09:48	40.7600	23.6700	16	e	MS	6.3	e
75	04.01.1935	14:41:23	40.2500	27.5000	35	g	MS	6.2	g
76	04.01.1935	16:20:00	40.2500	27.5000	35	g	MS	6.0	g
77	25.02.1935	02:51:30	36.0700	24.8300	67	e	MS	7.1	e
78	18.03.1935	08:40:47	36.0800	27.3000	83	e	MS	6.1	e
79	01.05.1935	10:24:35	39.5000	43.0000	35	g	MS	6.0	g
80	16.12.1937	17:35:37	35.0000	23.5000	100	g	MS	6.5	g
81	19.04.1938	10:59:20	39.4400	33.7900	10	b	MS	6.6	b

Table 3. Continued.

Id No	Date	Time	Latitude	Longitude	Depth	Reference	Type	Magnitude	Reference
82	20.07.1938	00:23:42	38.3000	23.6600	42	e	MS	6.1	e
83	22.09.1939	00:36:37	39.0700	26.9400	10	e	MS	6.6	e
84	26.12.1939	23:57:21	39.8000	39.5100	20	b	MS	7.9	b
85	29.02.1940	16:07:47	34.8400	25.4800	43	e	MS	6.0	e
86	07.05.1940	22:23:44	42.0300	43.7100	10	e	MS	6.0	e
87	30.07.1940	00:12:07	39.7500	35.5000	35	g	MS	6.2	g
88	20.01.1941	03:37:07	35.0000	34.0000	100	e	MS	6.5	e
89	23.05.1941	19:51:59	37.0700	28.2100	40	e	MS	6.0	e
90	10.09.1941	21:53:00	39.5000	43.0000	35	g	MS	6.0	g
91	13.12.1941	06:16:05	37.0000	28.0000	100	g	MS	6.0	g
92	28.10.1942	02:22:53	39.1000	27.8000	50	b	MS	6.0	b
93	15.11.1942	17:01:23	39.5500	28.5800	10	b	MS	6.1	b
94	20.12.1942	14:03:08	40.8700	36.4700	10	b	MS	7.0	b
95	20.06.1943	15:32:54	40.8500	30.5100	10	b	MS	6.6	b
96	26.11.1943	22:20:41	41.0500	33.7200	10	b	MS	7.2	b
97	01.02.1944	03:22:36	40.9000	32.6000	10	d	MS	7.3	d
98	25.06.1944	04:16:26	38.7900	29.3100	40	e	MS	6.0	e
99	06.10.1944	02:34:49	39.4800	26.5600	40	e	MS	6.8	e
100	20.03.1945	07:58:57	37.1100	35.7000	60	b	MS	6.0	b
101	02.09.1945	11:54:05	34.4300	28.6100	62	e	MS	6.4	e
102	09.12.1945	06:08:45	45.0000	26.5000	100	g	MS	6.0	g
103	04.06.1947	00:29:57	40.0900	23.9200	45	e	MS	6.0	e
104	30.08.1947	22:21:42	35.5000	23.3700	34	e	MS	6.4	e
105	09.02.1948	12:58:19	35.4100	27.2000	30	b	MS	7.2	b
106	29.06.1948	16:06:29	41.6000	46.4000	48	e	MS	6.1	e
107	24.07.1948	06:03:11	34.4900	24.4900	20	e	MS	6.4	e
108	11.09.1948	08:52:44	37.3800	23.2800	88	e	MS	6.2	e
109	23.07.1949	15:03:33	38.5700	26.2900	10	e	MS	6.6	e
110	17.08.1949	18:44:20	39.5700	40.6200	40	e	MS	6.7	e
111	13.08.1951	18:33:34	40.8800	32.8700	10	b	MS	6.9	b
112	17.12.1952	23:04:02	34.4700	24.2200	17	e	MS	6.4	e
113	18.03.1953	19:06:16	39.9900	27.3600	10	e	MS	7.2	e
114	07.09.1953	03:59:04	41.0900	33.0100	40	e	MS	6.0	e
115	10.09.1953	04:06:03	34.8000	32.5000	10	e	MS	6.3	e
116	19.04.1955	16:47:24	39.3100	23.0600	15	e	MS	6.2	e
117	16.07.1955	07:07:17	37.6500	27.2600	40	e	MS	6.8	e
118	12.09.1955	06:09:24	32.2000	29.6000	10	e	MS	6.1	e
119	20.02.1956	20:31:44	39.8900	30.4900	40	b	MS	6.4	b
120	16.03.1956	19:32:40	33.8000	35.6000	10	e	MS	6.0	e
121	09.07.1956	03:11:43	36.6900	25.9200	10	b	MS	7.4	b
122	09.07.1956	03:24:09	36.5900	25.8600	40	e	MS	6.5	e
123	24.04.1957	19:10:17	36.4300	28.6300	80	b	MS	6.8	b
124	25.04.1957	02:25:45	36.4200	28.6800	80	b	MS	7.1	b
125	26.05.1957	06:33:35	40.6700	31.0000	10	b	MS	7.1	b
126	13.12.1957	01:45:05	34.4100	47.6700	42	e	MS	7.1	e
127	16.08.1958	19:13:44	34.3800	47.8300	10	e	MS	6.7	e
128	14.05.1959	06:36:59	35.1100	24.6500	23	e	MS	6.1	e
129	23.05.1961	02:45:22	36.7000	28.4900	70	e	MS	6.3	e
130	15.09.1961	01:46:10	34.9800	33.8300	33	e	MS	6.0	e
131	24.03.1963	12:44:06	34.4400	47.8000	40	e	MS	6.0	e
132	16.07.1963	18:27:14	43.2500	41.5800	5	e	MS	6.4	e
133	18.09.1963	16:58:15	40.7700	29.1200	40	b	MS	6.3	b
134	14.06.1964	12:15:31	38.1300	38.5100	3	b	MS	6.0	b
135	17.07.1964	02:34:26	38.0500	23.6300	155	e	MS	6.0	e
136	06.10.1964	14:31:23	40.3000	28.2300	34	b	MS	7.0	b
137	09.03.1965	17:57:55	39.3400	23.8200	18	e	MS	6.3	e
138	09.04.1965	23:57:02	35.0600	24.3100	39	e	MS	6.1	e
139	19.08.1966	12:22:11	39.1700	41.5600	26	b	MS	6.9	b
140	20.08.1966	11:59:09	39.4200	40.9800	14	b	MS	6.2	b

Table 3. Continued.

Id No	Date	Time	Latitude	Longitude	Depth	Reference	Type	Magnitude	Reference
141	04.03.1967	17:58:09	39.2500	24.6000	60	e	MS	6.5	e
142	22.07.1967	16:56:58	40.6700	30.6900	33	e	MS	6.8	e
143	26.07.1967	18:53:00	39.5000	40.3000	10	d	MS	6.0	d
144	19.02.1968	22:45:42	39.4000	24.9400	7	e	MS	7.2	e
145	03.09.1968	08:19:53	41.8100	32.3900	5	b	MS	6.5	b
146	14.01.1969	23:12:06	36.1100	29.1900	22	e	MS	6.2	e
147	25.03.1969	13:21:34	39.2500	28.4400	37	e	MS	6.0	e
148	28.03.1969	01:48:30	38.5500	28.4600	4	e	MS	6.5	e
149	12.06.1969	15:13:31	34.4300	25.0400	22	e	MS	6.0	e
150	28.03.1970	21:02:24	39.2100	29.5100	18	e	MS	7.2	e
151	14.05.1970	18:12:24	43.0900	47.0700	13	e	MS	6.6	e
152	22.05.1971	16:43:59	38.8500	40.5200	3	e	MS	6.8	e
153	04.05.1972	21:39:57	35.1500	23.5600	14	e	MS	6.3	e
154	06.09.1975	09:20:12	38.5132	40.7741	31.9	e	MS	6.6	e
155	28.07.1976	20:17:44	43.1800	45.5700	18	e	Mw	6.2	h
156	24.11.1976	12:22:16	39.0800	44.0290	8.60	k	Mw	7.0	h
157	11.09.1977	23:19:23	34.9470	23.0900	22	k	MS	6.0	i
158	20.06.1978	20:03:23	40.7600	23.3010	8	k	Mw	6.2	h
159	15.05.1979	06:59:24	34.5820	24.4770	45.9	k	Mw	6.1	h
160	18.12.1980	12:34:15	35.8820	44.6360	20	k	Mw	6.1	h
161	04.03.1981	21:58:06	38.1870	23.2940	14.4	k	Mw	6.2	h
162	19.12.1981	14:10:53	39.1860	25.3090	14.5	k	Mw	6.8	h
163	27.12.1981	17:39:15	38.8660	24.9370	15	k	Mw	6.3	h
164	18.01.1982	19:27:25	39.9560	24.4300	10	k	Mw	6.6	h
165	05.07.1983	12:01:27	40.3110	27.2560	10	k	Mw	6.1	h
166	06.08.1983	15:43:56	40.1160	24.7490	20	k	Mw	6.6	h
167	30.10.1983	04:12:29	40.3310	42.1730	15	k	Mw	6.6	h
168	21.06.1984	10:43:44	35.3850	23.3320	46.9	k	Mw	6.2	i
169	05.05.1986	03:35:39	38.0010	37.7830	4.1	k	Mw	6.0	h
170	07.12.1988	07:41:25	40.9180	44.1200	5	k	Mw	6.7	h
171	29.04.1991	09:12:49	42.4210	43.6630	17	k	Mw	6.9	h
172	29.04.1991	18:30:42	42.4700	43.8530	10.1	k	Mw	6.1	h
173	15.06.1991	00:59:21	42.4030	44.0070	9	k	Mw	6.2	h
174	13.03.1992	17:18:40	39.7200	39.6320	22.2	k	Mw	6.6	h
175	23.10.1992	23:19:46	42.5650	45.0950	16	k	Mw	6.4	h
176	06.11.1992	19:08:09	38.0480	27.0040	9.8	k	Mw	6.0	h
177	23.05.1994	06:46:17	35.5470	24.7680	76	k	Mw	6.0	h
178	01.10.1995	15:57:17	38.0750	30.1420	30.9	k	Mw	6.4	h
179	20.07.1996	00:00:40	36.1980	27.0690	7	k	Mw	6.2	h
180	09.10.1996	13:10:52	34.5610	32.1440	22	k	Mw	6.8	h
181	27.06.1998	13:55:50	36.9358	35.3664	10	f	Mw	6.2	h
182	17.08.1999	00:01:39	40.7700	30.0040	15	k	Mw	7.6	h
183	07.09.1999	11:56:51	38.1048	23.6083	10	f	Mw	6.0	h
184	12.11.1999	16:57:21	40.8060	31.2260	11	k	Mw	7.1	h
185	06.06.2000	02:41:51	40.7340	33.0050	7	k	Mw	6.0	h
186	15.12.2000	16:44:44	38.6081	31.1972	5	f	Mw	6.0	h
187	26.07.2001	00:21:39	39.0810	24.2990	12	k	Mw	6.4	h
188	22.01.2002	04:53:52	35.4984	26.7399	100	f	Mw	6.1	h
189	03.02.2002	07:11:30	38.5270	31.2210	5	k	Mw	6.5	h
190	27.01.2003	05:26:25	39.4960	39.8410	15.1	k	Mw	6.0	h
191	01.05.2003	00:27:05	39.0100	40.4600	10	j	Mw	6.3	h
192	17.03.2004	05:21:02	34.6890	23.3117	40	f	Mw	6.0	h
193	08.01.2006	11:34:55	36.2690	23.3920	66	k	Mw	6.7	h
194	15.07.2008	03:26:35	35.8900	27.7930	52	k	Mw	6.4	h
195	01.07.2009	09:30:10	34.1472	25.5396	13.7	i	Mw	6.4	h
196	07.09.2009	22:41:00	42.5800	43.4500	15	i	Mw	6.0	h
197	08.03.2010	02:32:00	38.7700	40.0700	5	a	Mw	6.1	h
198	01.04.2011	13:29:10	35.5658	26.6019	80	f	Mw	6.1	h

Table 3. Continued

Id No	Date	Time	Latitude	Longitude	Depth	Reference	Type	Magnitude	Reference
199	23.10.2011	10:41:00	38.6890	43.4657	19.02	a	Mw	7.1	h
200	23.10.2011	20:45:34	38.6447	43.1275	6.79	a	Mw	6.0	h
201	10.06.2012	12:44:16	36.3600	28.9300	30	f	Mw	6.1	h
202	11.08.2012	12:23:00	38.4100	46.8100	10	f	Mw	6.5	h
203	11.08.2012	12:34:36	38.4800	46.7500	10	f	Mw	6.4	h

CONCLUSION

Many existing earthquake catalogues or various data for Turkey and surrounding have some special limitations and are not fulfil for earthquake hazard and risk assessments. In accordance with the needs, a sub-project launched to prepare a new catalogue under the Seismotectonic Map of Turkey Project.

For this purpose, an integrated database has been built in order to analyse all parameters acquired from the available 41 sources. The integrated database, around 37,000 earthquakes, was reassessed querying both cross correlation and spatial comparison to select earthquake parameters with less errors.

Detailed examination of the integrated database revealed that most of them have no information for parameters and a few are more reliable than the others or sole sources for certain periods. Therefore, some sources were preferred for some parameters and certain periods. Epicentral locations of $M \geq 5.0$ were also reappraised benefiting from the updated Active Fault Map (Emre et al. 2013) to provide high position credibility for selected earthquakes. Thus, an improved parametric earthquake catalogue has been created. The new parametric catalogue includes 12,674 events for the period between 1900 and 2012 in Turkish mainland and surrounding. A part of the catalogue of 203 events of large enough $M \geq 6.0$ is presented to be interest of earth scientists. Distribution of the epicentral locations follows major active structures in Turkish mainland and its vicinity. The seismic activity in the catalogue region is not only restricted along the major tectonic elements, but also consist with single fault segments.

The improved catalogue will provide important contribution for earthquake activities and related hazard and risk assessments in Turkey and for the wider its vicinity.

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LDG, Laboratoire De Détection Et De Géophysique/Cea, Fransa
MOS, Geophysical Survey Of Russıan Academy Of Sciences, Rusya
NAO, Stiftelsen Norsar, Kjeller, Norveç
NEIC, National Earthquake Information Center, U.S. Geologıcal Survey, America.
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