GEOFIZIKA VOL. 28 2011

Review paper
UDC 550.346

Losses due to historical earthquakes in the Balkan region: Overview of publicly available data

Biljana Abolmasov[1], *Milorad Jovanovski*[2], *Pavle Ferić*[3] *and Snježana Mihalić*[3]

[1] Faculty of Mining and Geology, University of Belgrade, Belgrade, Serbia

[2] Faculty of Civil Engineering, University "Ss. Cyrilus and Methodius", Skopje, The Former Yugoslav Republic of Macedonia

[3] Faculty of Mining, Geology and Petroleum Engineering, University of Zagreb, Zagreb, Croatia

Received 10 April 2010, in final form 23 May 2011

This study analyzes catastrophic losses due to earthquakes in the Balkan region. Analysis is based on the following data on earthquakes, collected from the OFDA/CRED International Disaster Database (Université Catholique de Louvain, Brussels, Belgium) for 1900 to 2010: numbers of fatalities, size of the affected population and costs of material damages. Catastrophic losses were caused by 62 earthquakes in countries within the region: Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Albania, Serbia, Romania, Bulgaria, Macedonia and Greece. The analysis shows that a significant number of people in the Balkan region were killed (4974) or were affected (2033723) by the earthquakes and that many countries suffered significant material damages (10410.16 million USD) during the analyzed period. The main disadvantage of using publicly available sources is the lack of consistent data on earthquake damages. A brief review of the most catastrophic earthquakes recorded in databases through the last 110 years is given, based on the data from publicly available databases.

Keywords: Balkan region, catastrophic earthquakes, natural disasters databases

1. Introduction

A relatively small number of countries have accurate and systematic data regarding the material damages and human losses due to the impact of natural disasters, even though at the 1989 World Geological Congress in Washington DC, it was decided that these data should be recorded and systematized (Abolmasov et al., 2010; Alcantara-Ayala, 2002). Moreover, majority of the countries in the Balkan region have signed the Hyogo Declaration of 2005 (International Strat-

egy for Disaster Reduction Programme 2005–2015, www.unisdr.org), which promoted the need to organize institutions and agencies at the regional, national and expert levels, which would participate in measures to decrease the impact of natural disasters on property and population. Access to information is very important for all aspects of disaster risk reduction and related management activities, as well as regional cooperation.

The Balkan region is one of the most seismically active regions in Europe, where major material damages and human losses due to earthquakes have been recorded throughout history. A survey of the seismicity of the Balkan region was carried out by UNESCO in the mid-1970s, which contributed a summary of the material available at that time for the assessment of regional seismicity (Shebalin et al., 1974). Seismic maps for a few events before 1900 and a parametric catalog were published, but they must now be used with caution (Ambraseys et al., 2002). According to Albini (2004), data on the major seismicity ($I_0 \geq 7$) up to the early 19th century are contained in the following parametric catalogs published between 1974 and 1997: Papazachos and Papazachou (1989, 1997) cover the area of Montenegro, Albania, Epirus and Corfu (GR) from 550 BC to 1986; Sulstarova and Kociu (1975) cover Albania and Epirus (GR) from the 3rd century BC until 1970; Herak (1995, unpublished) covers Croatia from 373 BC to 1993. A thorough analysis of these catalogs with respect to earthquake parameters has been performed within the framework of the project "A Basic European Earthquake Catalogue and a Database – BEECD" (Albini and Stucchi, 1997; also at http://emidius.mi.ingv.it/BEECD), resulting in the compilation of the parametric European Catalogue of Damaging Earthquakes for the time period 1400–1899 (EuCaDE, parametric catalog of the events above the damage threshold, $I_0 / I_x \geq 5/6$, $M \geq 4.0$). The Croatian Earthquake Catalogue for the period 1908–1992 was revised by Herak et al. (1996), and the Croatian Macroseismic Data Base began to be compiled in 1995 (Sović, 1999). A catalog of seismicity in Greece and the adjacent areas for the 20th century is published in Burton et al. (2004), and a new earthquake catalog for Bulgaria and the conterminous Balkan region was compiled by Bayliss and Burton (2007).

Although there has been great improvement in the organization of seismological services in relation to equipment, standardization and communication between regional agencies over the last twenty years, there have been very small advances in regards to the publishing of information on the impact of earthquakes on property and populations on the local and regional levels.

This paper shows the results of the analysis of data collected from the database of the Université Catholique de Louvian (EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.be, Université Catholique de Louvain, Brussels, Belgium), aimed at systematizing recorded data on material and human losses due to catastrophic earthquakes in the Balkan region for 1900–2010. Additional information and reviews are obtained from other public sources: United States Geological Survey (USGS, http://earthquake.usgs.gov), International Strategy for Disaster Reduction-ISDR (PreventionWeb,

http://www.preventionweb.net) and Utsu's (2002) global compilation of deadly earthquakes.

Countries that were included in this analysis are: Slovenia, Croatia, Bosnia and Herzegovina (BIH), Montenegro, Albania, Serbia, Romania, Bulgaria, Macedonia and Greece. The European part of Turkey was not included in the analysis, as there were no data available for that part of Turkey in the databases used. On the basis of different sources, it is possible to gain insight into the public availability of the information and consistency of the data on earthquake damages. The analysis also resulted in an overview of the most significant losses due to historical earthquakes from 1900–2010 in the Balkan region.

2. Sources of input data

All countries in the region have professional institutions or agencies, established at the national level, which monitor and record seismic activity within the country: Environmental Agency of the Republic of Slovenia (http://www.arso.gov.si), Seismological Survey of the Republic of Croatia (http://www.gfz.hr), Federal Hydro-Meteorological Survey of BIH (http://www.fhmzbih.gov.ba/latinica/seizmo-bih.php); Seismological Observatory (http://www.seismo.co.me); Seismological Institute (http://www.academyofscience.net); Seismological Survey of Serbia (http://www.seismo.gov.rs); National Institute for Earth Physics (http://www.inftp.ro); Geophysical Institute of the Bulgarian Academy of Science (http://www.geophys.bas.bg); Seismological Observatory (http://www.pmf.ukum.edu.mk**),** Central Seismological Station (http://www.geo.auth.gr) and Institute of Geodynamics (http://www.gein.noa.gr). Information about earthquakes, available on the webpages of the aforementioned institutions or agencies, differs according to the organization. Also, certain countries in the region submit earthquake data annually to national statistical services (i.e., National Statistical Bureaus), which disseminate this information through webpages (e.g., Statistical Office of the Republic of Slovenia: http://www.stat.si). However, in the vast majority of cases, earthquake information found on the webpages of seismological institutions or statistical bureaus do not contain data on the material damages and human losses associated with particular earthquakes. Some of the aforementioned internet sources also lack information available in English.

2.1. List of deadly earthquakes for 1500–1999 by Utsu (2002)

In Table 1, a subset of data from the global list of deadly earthquakes, from 1500 to 1999, is given for the Balkan region (Utsu, 2002). The list was compiled by selecting the earthquakes for which at least 50 people were reported killed, or for which many were reported killed, when a more specific number was not available. Utsu (2002) collected the data on individual earthquakes from various catalogs, research articles, reports on global and regional

Table 1. A list of deadly earthquakes in the Balkan region selected from the list of deadly earthquakes in the World for 1500–1999 compiled by Utsu (2002).

Year	Month/day	h:min	Lat.	Long.	M	Deaths	Remarks
1508	5/29		35.2	25.1	7.1	300	Greece: Ierapetra, Megalokastron (Crete) [T]
1511	3/26	14:40U	46.2	13.4	6.9	many	Slovenia: Idrija/Italy: Friuli D = 3T / 6T / 12T
1514	4/16		37.7	21.	6.5	many	Greece: Zakinthos (I = 10)
1544	4/22		38.8	22.6	6.8	many	Greece: Lamia (I = 9) [F?]
1566	7/11		39.0	21.7	6.5	many	Greece: Karpenisi (I = 8)
1590	9/05		45.9	16.3		many	Croatia: Zagreb/Hungary: Nagy Kanizsa (I = 10)
1612	11/08		34.9	25.1	7.5	many	Greece: Crete (I = 8) [T]
1613			35.3	25.1		many	Greece: Iraklion (Crete) (same as 1612/11/08?)
1622	5/05		37.6	21.0	6.6	many	Greece: Ionian Sea, Zakinthos (I = 9) [T]
1629	3/10	09:00L	35.1	23.7	7.0	many	Greece, Crete Cythera Date = 2/27? 3/07? 3/09? [T]
1630	7/22		38.3	20.9	6.9	many	Greece: Levkas, Cephalonia, Itaca (I = 9–11)
1633	11/05	13:00L	37.6	21.0	6.9	many	Greece: Zakinthos (Zante) (I = 10) [T]
1636	9/30		38.0	20.7	7.2	520	Greece: Cephalonia, Zakinthos (I = 10)
1658	8/24		38.3	20.5	6.8	320	Greece: Cephalonia (I = 10)
1665	1/		35.0	25.1	6.7	many	Greece: Crete (I = 10)
1667	4/06	08:00U	42.6	18.1	7.2	5000	Croatia: Dubrovnik (I = 10) [T]
1674	1/01		39.5	20.0	6.5	200	Greece: Corfu
1723	2/22	02:00L	38.6	20.7	7.0	many	Greece: Ionian Sea, Levkas (I = 9–10) [T]
1748	5/25	15:00L	38.2	22.2	6.8	many	Greece: Aeghio (I = 9) [T]
1750	6/07		36.3	22.8	7.0	2000	Greece: Kythera, Morea, Cerigo (I = 10)
1750	12/17		45.2	14.2		many	Croatia: Rijeka (Fiume) (I = 9) Date=9/17? [T]
1759	6/22	22:30L	40.7	23.1	6.5	many	Greece: Thessaloniki (I = 9) [F]
1767	7/11		38.2	20.3	7.2	253	Greece: Lixouri (Cephalonia) (I = 10)
1786	2/05		39.6	19.9	6.6	126	Greece: Cofu, Argos (I = 9–10) D=120
1804	1/08		38.3	21.8		many	Greece: Patrai (Patras) (I = 9) [T]
1810	2/16	21:15U	35.7	25.0	7.8	2000	Greece: Iraklion (Crete) (I = 10)
1821	1/06	17:15U	37.8	21.2	6.5	many	Greece: Zakinthos, Lala (Morca) Date = 1/09? [T]
1823	10/		42.7	18.2		many	Croatia: Dubrovnik
1825	1/19	11:00U	38.8	20.7	6.8	58	Greece: Levkas, Amaxiki, Preveza D = 34 [T]
1851	2/28	16:58L	36.4	28.6	7.2	many	Greece: Rhodes, Makri/Turkey: Fetiye (I = 10) [T]
1856	10/12	00:45U	35.5	26.0	8.3	538	Greece: Crete, Kasos, Karapathos (I = 11) D = 20 [T]
1865	7/23	21:30L	39.4	26.2	6.7	many	Greece: Lesbos (I = 9–10)
1866	1/02	09:00U	40.4	19.5	6.5	60	Albania: Narta, Vlore, Kanina (I = 9) [T]
1867	2/04	04:19U	38.2	20.4	7.3	224	Greece: Cephalonia (I = 11) D = 200 Time=4:15L?
1867	3/07	16:00U	39.3	26.2	6.8	500	Greece/Turkey: Lesbos (I = 10) D = 150
1870	8/01	00:41L	38.5	22.6	6.8	117	Greece: Gulf of Corinthos, Phokida, Arachova
1873	2/01		37.5	26.5		many	Greece: Samos (2/01–03)
1881	4/03	11:40L	38.3	26.2	6.5	7866	Greece: Khios (I = 9 or 11) D = 3541/4000/4181
1894	4/20	14:52U	38.6	23.0	6.7	255	Greece: Malesina, Lokris (D incl. 4/27?)
1894	4/27	17:42U	38.7	23.0	7.2	255	Greece: Lokris, Constantinos (I = 8–10) [FT]
1895	5/14	05:00U	39.4	20.5	6.6	many	Greece: Margariti, Paramithia/Albania M = 7.5?
1898	7/02	04:20U	43.6	16.7		many	Croatia: Caparice, Grab, Trilj, Vojnic, Losuta
1905	6/01	04:42U	42.1	19.5	6.6	120	Albania: Shkoder (I = 9–10)
1905	11/08	22:06U	40.3	24.4	7.5	many	Greece: Chalkidiki, Athoshalb D = 2000 6.8S
1913	6/14	09:33U	43.1	25.8	6.8	500	Bulgaria: Tirnovo, Orahavitza (I = 10–11)
1920	11/26	08:51U	40.3	20.0	6.3	200	Albania: Tepelene, Gjirokaster D = 600 [T]
1922	3/24	12:22U	44.5	20.3	6.0	many	Serbia, Belgrade, Lazarevac (I = 9–10)
1927	2/14		43.0	18.0	6.1	50	Croatia (I = 7–8)

Table 1. Continued.

Year	Month/day	h:min	Lat.	Long.	M	Deaths	Remarks
1928	4/14	09:00U	42.2	25.3	6.8	107	Bulgaria: Plovdiv P. (I = 9–10) D = many [F]
1928	4/18	19:22U	42.1	25.0	7.0	103	Bulgaria: Plovidiv (I = 8) D = 107 (incl. Apr. 14?)
1931	1/28	05:55U	40.6	20.7	5.9	100	Albania: Corce (I = 9) D = 4/90
1932	9/26	19:20U	40.5	23.8	7.0	491	Greece: Hierissos (Chalkidiki) (I = 10) [T?]
1932	9/29	03:57U	41.0	23.2	6.2	318	Greece: Sohos (Chalkidiki) (I = 9–10)
1933	4/23	05:58U	36.8	27.3	6.6	74	Greece: Kos (I = 9–10) [T?]
1956	7/09	03:11U	36.6	26.0	7.5	53	Greece: Santorini, Amorgos (I = 9) [T] 7.7S
1963	7/26	04:17U	42.0	21.4	6.1	1070	Macedonia: [Skopje EQ] (I = 9–10) D = 1200
1977	3/04	19:21U	45.8	26.8	7.2	1581	Romania: Vrancea, Bucharest D = 1387 7.1B 7.5W
1978	6/20	20:03U	40.6	23.3	6.5	50	Greece: [Thessaloniki EQ] (I = 8–9 = D = 45 [F] 6.2W
1979	4/15	06:19U	42.1	19.2	6.9	129	Motenegro/Albania D = 156 6.9W
1999	9/07	11:56U	38.1	23.6	5.8	143	Greece: Athens area 6.0W

Explanation: [F] – earthquake has associated surface faulting; [T] – earthquake followed by tsunami; S – surface-wave magnitude, M_s, B – body-wave magnitude m_B, for intermediate-depth earthquakes; W – moment magnitude M_W

earthquakes and many other sources. Because the materials on historical earthquakes are of limited accessibility, and some material may contain various types of inaccuracies, this list is neither complete nor entirely accurate, especially for the older events. The numbers of deaths for a given earthquake from different sources often differ very widely. In such cases, additional estimates have been included in the column 'Remarks' in the form of D = 850 / 2T / 1000 s (2T = 2000, 1000 s = thousands), for example. Some of questionable information are marked by question mark in the form of Date = 2/27? 3/07? 3/09?, for example.

Earthquake data compiled by Utsu (2002) show there are many historical records of deadly earthquakes, but also there has been no unified approach in collecting data because of the long time period and differing sources, particularly for the period 1900–1999.

2.2. A list of deadly earthquakes from United States Geological Survey, 1904–2010

The United States Geological Survey (USGS) records data on the number of deaths in catastrophic earthquakes in the USA and globally. The sources of the data on catastrophic earthquakes, organized in the Historic World Earthquakes records, are not known. Table 2 lists all available records for the Balkan region.

From Table 2, it can be seen that the data for many catastrophic earthquakes of the Balkan region are missing before 1977 year, as well as basic information about many earthquakes, such as the time of the event and the location of the epicenter, even for the records from the second half of20th century. Data on the affected population or the amount of material damages are partially publicly available through the USGS database.

Table 2. Summary of deadly earthquakes in the Balkan region from the United States Geological Survey – USGS (http://earthquake.usgs.gov), 1904–2010.

Country	Year	Month/day	h:min	Lat.	Long.	Magnitude	Deaths
Greece	1904	08/11				6.2	4
Romania	1940	11/10		45.8	26.7	7.3	1000
Greece	1953	08/12				7.1	455
Greece	1954	04/30	13:02UTC			7.1	31
Macedonia	1963	07/26		42.1	21.4	6.0	1100
Greece	1965	03/31	09:47UTC			6.2	6
Greece	1965	04/05	03:12UTC			6.2	32
Greece	1965	07/06	03:18UTC			6.3	1
Greece	1967	05/01				5.9	9
Romania	1977	03/04	19:21UTC	45.7	26.7	7.2	1500
Greece	1978	06/20	20:03UTC	40.7	23.2	6.6	50
Greece	1978	07/04	22:23UTC	40.7	23.0	5.7	1
Montenegro	1979	04/15	06:19UTC	42.1	19.2	6.9	121
Greece	1981	02/24	20:53UTC	38.2	22.9	6.8	16
Greece	1981	03/04	21:58UTC	38.2	23.4	6.6	1
Greece	1981	03/07	11:34UTC	38.2	23.3	4.8	1
Greece	1981	03/10	15:16UTC	39.5	20.7	5.6	2
Macedonia	1983	02/25	18:22UTC	41.9	21.5	4.7	12
BIH	1984	05/13	12:45UTC	42.9	17.7	5.1	1
Romania	1986	08/30	21:28UTC	45.5	26.3	6.4	2
Greece	1986	09/13	17:24UTC	37.0	22.1	5.7	20
Bulgaria	1986	12/07	14:17UTC	43.3	25.9	5.5	3
Romania	1990	04/30	10:40UTC	45.8	26.7	7.1	9
Greece	1990	12/21	06:57UTC	41.0	22.3	5.8	1
Romania	1991	07/12	10:42UTC	45.3	21.1	5.3	2
Greece	1995	06/15	00:15UTC	38.4	22.3	6.5	26
Serbia	1998	09/29	22:14UTC	44.2	20.1	5.2	1
Greece	1999	09/07	11:56UTC	38.1	23.6	6.0	143
Serbia	2002	04/24	10:51UTC	42.4	21.5	5.7	1
Slovenia	2004	07/12	13:04UTC	46.2	13.6	5.2	1
Greece	2008	06/08	12:25UTC	37.9	21.5	6.4	2
Greece	2009	01/04	05:10UTC	36.7	22.3	4.3	1
Serbia	2010	11/03	00:56UTC	43.7	20.7	5.5	2
						Total	4557

2.3. EM-DAT database: losses due to catastrophic earthquakes, 1900–2010

The most complete information about natural disasters in general, and about earthquakes in the region in particular, was found in the database EM-DAT: The OFDA/CRED International Disaster Database (http://www.emdat.be) from the Université Catholique de Louvain, Brussels, Belgium. The

Table 3. Summary of recorded and analyzed earthquake data from EM-DAT: The OFDA/CRED International Disaster Database (Université Catholique de Louvain, Brussels, Belgium) for 1900–2010.

Country	Location	Date (d/m/y)	Killed	Affected	Damage, million USD
Serbia	Kopaonik	17.05.1980.	–	5100	n/a
	Gnjilane	24.04.2002.	1	100	n/a
	Kraljevo	03.11.2010.	2	27030	132.26
		Total	3	32230	132.26
Croatia	Ston, Slano	05.09.1996.	–	2000	n/a
		Total	–	2000	n/a
Slovenia	Bovec	30.05.1990.	8	120	n/a
	Bovec, Trenta, Kobarid	12.04.1998.	–	700	n/a
	Kobarid, Bovec	12.07.2004.	1	605	10
		Total	9	1425	10
BIH	Banja Luka	26.10.1969.	15	286116	50
	Banja Luka	13.08.1981.	–	44	n/a
		Total	15	286160	50
Macedonia	Skoplje	26.07.1963.	1100	3383	600
	Debar	30.11.1967.	7	21870	20
	Skoplje, Dolno, Kolicani	25.02.1983.	12	–	n/a
	Demir Kapija	28.09.1985.	–	1516	n/a
		Total	1119	26769	620
Montenegro	No data on location	03.11.1968.	1	15030	38.6
	Bar	15.04.1979.	121	310100	450
	Kotor-Ulcinj area	24.05.1979.	–	80	n/a
		Total	122	325210	488.6
Greece	Ionian Islands	12.08.1953.	455	–	100
	Central	30.04.1954.	31	200	n/a
	Alonisos, Skopelos	09.03.1965.	38	30253	8
	Eurytania region	05.02.1966.	1	11050	4
	Megalopos	01.09.1966.	1	15123	14
	North West Mountains	01.05.1967.	9	16583	5
	Limnos, Agios Efstratios	20.02.1968.	19	7618	0.6
	Thessaloniki area	20.06.1978.	50	600100	250
	No data on location	01.06.1979.	48	–	n/a
	Volos (Magnisia province)	12.07.1980.	1	17	n/a

Table 3. Continued.

Country	Location	Date (d/m/y)	Killed	Affected	Damage, million USD
Greece	Athens-Corinth area	24.02.1981.	22	80400	900
	Grecce-Albania border	10.03.1981.	2	450	n/a
	Vonitsa area	23.03.1983.	-	487	n/a
	Preveza region	21.08.1985.	-	186	n/a
	Kalamata	13.09.1986.	20	45300	745
	Near Killini	16.10.1988.	0	25	n/a
	Goumnesia	21.12.1990.	1	60	n/a
	Kanalaki	16.06.1990.	-	1	n/a
	Pyrgos-Amalias area	27.03.1993.	1	1516	n/a
	Patras	14.07.1993.	-	605	n/a
	Kozani, Thessaloniki	13.05.1995.	26	15060	450
	Aiyion	15.06.1995.	26	13900	422.7
	Konitsa	06.08.1996.	0	1500	n/a
	Athens Suburbs of Menidi	07.09.1999.	143	115139	4200
	Mihalitsi, Mitikas	26.05.2000.	-	600	n/a
	Aegean Sea	26.07.2001.	-	300	n/a
	Bartholomio	02.12.2002.	-	167	n/a
	Lefkada	14.08.2003.	-	50	n/a
	Achaie, Elide	08.06.2008.	2	3708	n/a
		Total	896	960398	7099.3
Romania	Vrancea, Bucharest	10.11.1940.	980	-	10
	Bucharest	04.03.1977.	1641	386300	2000
	Vrancea	30.08.1986.	2	500	n/a
	Bucharest-Braila-Brasov	30.05.1990.	9	700	n/a
	Vouteg (Timis province)	02.12.1991.	-	4005	n/a
	Orosova area	18.07.1991.	-	1845	n/a
		Total	2632	393350	2010
Bulgaria	Plovdiv	14.04.1928.	107	-	n/a
	Svishtov, Ruse	04.03.1977.	20	165	n/a
	Strazhitsa (Tyrnovo region)	07.12.1986.	3	3060	n/a
	North	30.05.1990.	1	-	n/a
	Murgovo area	20.02.2006.	-	527	n/a
		Total	131	3752	n/a
Albania	Shupenze	30.11.1967.	11	134	n/a
	Northern	15.04.1979.	35	350	n/a
	Lushnje	16.11.1982.	1	5005	n/a
	Tirana	09.01.1988.	-	690	n/a
	Kukes	20.09.1998.	-	2100	n/a
	Peshkopia	07.09.2009.	-	150	n/a
		Total	47	8429	n/a
		Total	**4974**	**2039723**	**10410.16**

EM-DAT database contains data on the number of fatalities, size of the affected population and information about the costs of material damage expressed in US dollars (USD) for each reported event. A search of the database can be performed by several criteria. For this analysis, a search by "Disaster/Type/Country List" criterion for each of the countries in the region was performed. Results are presented in Table 3.

Terms have been defined as follows: "killed" is the total number of people confirmed dead and those missing and presumed dead; "affected" is the total number of people requiring immediate assistance during period of emergency (this may include those displaced or evacuated) and "estimated damage" is the economic impact of a disaster, given in current USD.

During data collection for countries in the Balkan region, it was necessary to pay special attention to the data for the countries of the former Yugoslavia (Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Serbia and Macedonia). For 1900–1990, all the data are in a single database and after that period, data were organized in a separate database for each new country, depending on the date of the country's independence from the former Yugoslavia. For example, information for Serbia and Montenegro contained in three databases: from 1900 to 1990, they are in the database for Yugoslavia; from 1990 to 2006, they are in the database for Serbia and Montenegro; after 2006, they are in separate databases for the two countries. Data for Croatia, Slovenia, Macedonia and Bosnia and Herzegovina are found in separate databases under the corresponding names of the independent countries after 1990. During the data collection process, particular care was taken to extract data from the joint ex-Yugoslavian database in accordance with recent political organization.

3. Analysis of selected data sets

Collection of data from EM-DAT was performed covering the period from 1900 to 2010 for the following countries of the Balkan region: Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Albania, Serbia, Romania, Bulgaria, Macedonia and Greece. There were a total of 62 earthquakes with information on the number of fatalities, affected population and material damages (Table 3). Considering that the largest amount of data was collected from EM-DAT, it was evident that a relatively small number of earthquakes have information on material damages, and there is information on human losses and affected population for only the most catastrophic earthquakes. Furthermore, information is missing for certain countries and certain years, particularly in the category of material damages, leading to the unrealistic representation of losses suffered by certain countries due to the impact of local earthquakes.

Analysis of the data from the List of Deadly Earthquakes (Utsu, 2002) for the Balkan region shows that 20592 people died from 1508 to 1900, while 5089

Table 4. Summary of recorded data for each country in the Balkan region for 1900–2010 from the sources (1) Utsu (2002); (2) USGS and (3) EM-DAT: The OFDA/CRED International Disaster Database (Université Catholique de Louvain, Brussels, Belgium). The percentage of earthquake loss per country is based on the EM-DAT database.

	No. of deaths		1900–2010 (EM-DAT)					
Country	1905–1999 (Utsu, 2002)	1904–2010 (USGS)	Killed	%	Affected	%	Material damage (million USD)	%
Albania	420	–	47	1	8429	1	–	0
Bulgaria	710	3	131	3	3752	0	–	0
BIH	–	1	15	0	286160	14	50.00	0
Croatia	50	–	0	0	2000	0	–	0
Greece	1129	802	896	18	960398	47	7099.30	69
Macedonia	1070	1112	1119	23	26769	1	620.00	6
Montenegro	129	121	122	2	325210	16	488.60	5
Romania	1581	2513	2632	53	393350	19	2010.00	19
Serbia	–	4	3	0	32230	2	132.26	1
Slovenia	–	1	9	0	1425	0	10.00	0
Total	5089	4557	4974	100	2039723	100	10410.16	100

people lost their lives from 1905 to 1999. For many historical earthquakes, there are no details on the number of dead, only a description of "many", or unclear or imprecise data in the "remarks" section.

According to the data in the USGS database from 1904 to 1999, the total number of deaths is 4557, although it should be noted that only the most catastrophic earthquakes of the 20th century have been listed.

Utsu (2002) and the USGS only completely reported the number of fatalities and there are significant discrepancies between the two sources, particularly for the same event from 1900 to 1999 (see Tables 1 to 3). A compilation of data from all three data sources for 1900–2010 is presented in Table 4. Data from EM-DAT were chosen for further analysis because of uniform criteria used in the database (Guha-Sapir, 2008; Rodriquez et al., 2009).

The analysis shows that the total number of fatalities due to earthquakes in the Balkan region is 4974. In relation to the total number of earthquake fatalities in the Balkans, the largest percentage of deaths occurred in Romania – 2632 people (53%), followed by Macedonia with 1119 (23%) and Greece with 896 deaths (18%), which summed to 94% of the total number of deaths in the entire region (Table 3).

Individually, largest number of people died in the earthquake in Bucharest, Romania on March 4, 1977, when 1641 people died in Romania and 20 died in Bulgaria. The second most devastating earthquake in the region, based on the number of fatalities, was in Skopje, in the former Yugoslavia, when 1100 people lost their lives (Figure 1A). It is interesting to note that in relation to the total number of earthquake fatalities in Romania, 97% of the

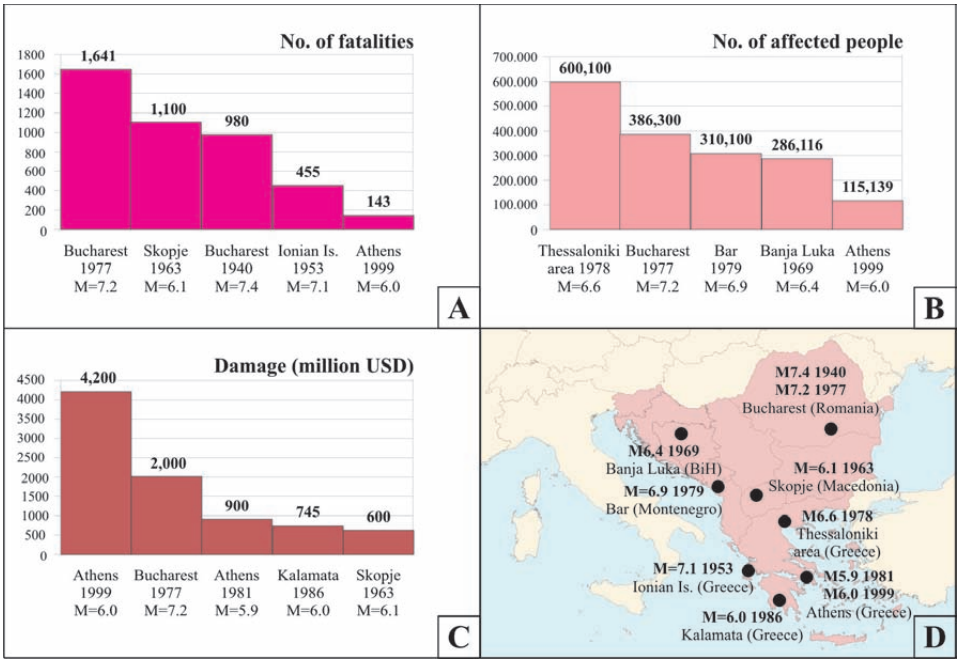


Figure 1. (A) Top five events by number of fatalities for 1900–2010; (B) Top five events by number of affected people for the period 1900–2010; (C) Top five events by material damage in millions USD for 1900–2010; (D) Geographical distribution of aforementioned earthquakes events. Source: EM-DAT: The OFDA/CRED International Disaster Database (Université Catholique de Louvain, Brussels, Belgium).

deaths in 1904–1999 were from only two events – the first on November 10, 1940, when 980 people died, and the second in 1977 when 1641 people perished. Both of these earthquakes were in the same epicentral area of the Vrancae region (Figure 1A).

Analysis of the population affected by the earthquakes shows that the largest number of affected people in the analyzed period was in Greece, i.e., 960398 people, representing 47% of the total affected population. This is followed by Romania with 393350 people affected (19%), Montenegro with 325210 (16%) and Bosnia and Herzegovina with 286160 people, representing 14% of the total affected population (Table 4). The single earthquake that affected the largest number of people (600100) was in Thessaloniki on June 20, 1978, followed by the earthquake in Bucharest on March 4, 1977 with 386300 affected people reported. Out of the earthquakes in the former Yugoslavia, the largest population affected by a single earthquake was in Bar on April 15, 1979 (Montenegro), when 310100 people were by an earthquake, followed by the earthquake in Banja Luka (Bosnia and Herzegovina) on October 26, 1969, which affected 286116 people (Figure 1B).

Analysis of the total material damages caused by earthquakes shows 10397.2 million USD was lost overall in the Balkan region. Unfortunately, this data category is missing the largest proportion of information, as there are no material damages, which should not imply that there was no damage. Certain countries have not supplied details on material damages for particular periods (e.g., Serbia from 1990 to present), not only for earthquakes, but for other disasters as well. For this reason, the results obtained from this analysis are not complete, and represent only a part of the real material damages caused by earthquakes during the analyzed period. Based on the available data, the greatest material losses in the analyzed period were suffered by Greece with 7099.3 million USD (68% of the total costs listed), followed by Romania with 2010 million USD (19% of the total cost), Macedonia with 620 million USD (6%) and Montenegro with 488.6 million USD in damages (5%) (Table 4). Individually, the largest economic damage was caused by the earthquake in Athens on September 7, 1999 with 4200 million USD in damages, followed by the earthquake in Bucharest on March 4, 1979 with 2000 million USD in damages (Figure 1C).

Apart from this analysis, data on the number of fatalities, affected people and cost of material damages have been analyzed decadally for the entire period from 1900 to present. The results of the analysis show that the largest number of deaths and people affected were reported in the period 1970–1979, and 1960–1969 respectively (Figure 2). After this period, the number of fatalities and the size of the affected population were significantly lower. However, the costs of material damages has grown in recent decades (Figure 2), most likely caused by the general growth and concentration of material wealth, primarily in larger urban environments, making them more susceptible to material damages.

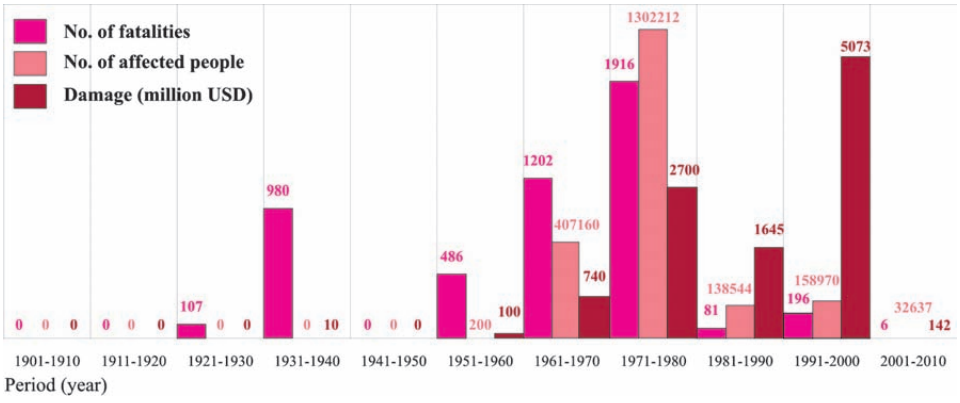


Figure 2. Total number of fatalities, affected population and total damages (in million USD) from earthquakes in the Balkan region from 1900–2010 by decade. Source: EM-DAT: The OFDA/CRED International Disaster Database (Université Catholique de Louvain, Brussels, Belgium).

4. Summary of catastrophic earthquakes

Based on analysis of data from the EM-DAT database, the most catastrophic earthquakes from 1900–2010 in the Balkan region were the following: M7.4 November 10, 1940 earthquake in Bucharest, Romania (Vrancea); M6.1 July 26, 1963 earthquake in Skopje, Macedonia (former Yugoslavian Republic); M6.4 October 26, 1969 earthquake in Banja Luka, Bosnia and Herzegovina (former Yugoslavian Republic); M7.2 March 4, 1977 earthquake in Bucharest, Romania; M7.0 April 15, 1979 earthquake in Bar, Montenegro (former Yugoslavian Republic); M6.5 June 20, 1978 earthquake in Thessaloniki, Greece; M6.0 September 7, 1999 earthquake in Athens, Greece (Figure 1D). A brief summary of the losses due to these earthquakes is given based on data from USGS World Earthquake Information and other available sources.

Earthquake: M7.4 November 10, 1940 earthquake in Bucharest, Romania (Vrancea)

Many buildings were destroyed and thousands of people were injured in the Bucharest-Galati area. Nearly all buildings were destroyed or heavily damaged in the Prahova River Valley and in Ploiesti, partly due to fires that broke out in the local oil refineries. Severe damages occurred in Moldavia. Damage also occurred in Bulgaria and at Chernovtsy, Dnipropetrovsk and Odessa (Russia) and in the Ukraine. The earthquake was felt from Marseille, France to Moscow and St. Petersburg, Russia, and at least as far south as Istanbul, Turkey (Source: USGS – http://earthquake.usgs.gov/earthquakes/world).

Earthquake: M6.1 July 26, 1963 earthquake in Skopje, Macedonia (former Yugoslavian Republic)

Approximately 75% of the buildings in Skopje were destroyed or severely damaged and more than 4000 people were injured. The heaviest damage occurred to buildings on alluvium in the Vardar River Valley. There was little damage outside Skopje, indicating the quake was very shallow and located almost directly under the city. The Illyrian city of Scupi was destroyed by an earthquake in 518. It was rebuilt nearby and briefly named Justiniana Prima, and later named Skopje. It was called Uskub while it was part of the Ottoman Empire, and was destroyed again by an earthquake in 1555 (Source: USGS http://earthquake.usgs.gov/earthquakes/world).

According to Milutinović (2007), the cost of damages to buildings was tremendous. The functional loss of residential buildings in a 1630609 m^2 area (private residences included) was estimated at 76.8%, leaving 75.5% of Skopje's inhabitants homeless. Approximately 22.6% of buildings remained undamaged or slightly damaged, therefore only those could be used for their intended function immediately after the earthquake. Public buildings, schools, hospitals, industrial and other public buildings also suffered very heavy damage, similar to those experienced by residential buildings. The total direct losses estimated by the Federal Commission of the Government of the former

SFR Yugoslavia amounted to 1.0 billion 1963 USD. The restitution value of direct material losses was estimated at 1.2 billion USD, which corresponded to approximately 15% of the GDP of the former SFR Yugoslavia for the 1962 fiscal year. The 1962 economy of the SR Macedonia contributed 10% of the GDP of the former SFR Yugoslavia, thus the direct losses caused by July 26 Skopje earthquake amounted to 1.5–2.0% of the GDP of the SR Macedonia.

Earthquake: M6.4 October 26, 1969 earthquake in Banja Luka, Bosnia and Herzegovina (former Yugoslavian Republic)

The earthquake that struck Banja Luka on October 26, 1969 affected an area of 9000 km^2 with seismic intensities of VII, VIII and IX on the MCS scale. They killed 15 people, left 1117 people in Banja Luka slightly to severely injured and injured fifteen people in other municipalities of the Krajina Region. 86000 apartments, 266 schools and 592 cultural, health, social and public facilities were completely destroyed or severely damaged (Source: http://earthquake-report.com/2011/04/29/m-5-earthquakes-3/).

Earthquake: M7.2 March 4, 1977 earthquake in Bucharest, Romania

This earthquake was centered approximately 170 km northeast of Bucharest and had a magnitude of 7.2. It killed 1500, injured approximately 10500 and caused extensive damage in Bucharest and other parts of Romania. Twenty people were reported dead, and 165 were reported injured in Bulgaria. Injuries and damages were reported in Yugoslavia. Damage was reported in the Soviet Republic of Moldavia. This earthquake was felt from Rome to Moscow and from Turkey to Finland (Source: USGS – http://earthquake.usgs.gov/earthquakes/world).

Earthquake: M7.0 April 15, 1979 earthquake in Bar, Montenegro (former Yugoslavian Republic)

This earthquake measured 7.0 on the Richter scale and IX on the Mercalli intensity scale. It occurred on April 15, 1979, 15 km from the Montenegrin coast between Bar and Ulcinj. By the end of the catastrophe, 101 people died in Montenegro, 35 died in Albania and over 100000 people were left homeless. According to a 1984 UNESCO report, a total of 1487 cultural heritage objects were damaged, nearly half of which consisted of households and another 40% consisted of churches and other sacred properties. Only 30% of the 1487 damaged objects were destroyed. Over 1000 cultural monuments suffered damage, as well as thousands of works of art and valuable collections. Initial estimates of the cost of damaged cultural property were approximately 10.5 billion USD, which is just under 15% of the total earthquake damage. Corrected for inflation, this is the equivalent of 31 billion 1984 USD. To help meet the total costs of the disaster, the government created a statutory fund whereby each worker in the SFR Yugoslavia contributed 1% of their monthly salary towards the restoration effort during the ten year period from 1979 to 1989 (Source: Montenegro Earthquake – The Conservation of the Historic Monuments and Art Treasures, UNESCO, 1984).

Earthquake: M6.5 June 20, 1978 earthquake in Thessaloniki, Greece

The June 20, 1978 M6.5 earthquake in Thessaloniki was one of the major earthquakes in Greece from an engineering point of view. Forty-seven people lost their lives, and approximately 150 people were injured. The major loss of life occurred when a seven-story concrete-frame apartment building collapsed, killing 37 people. In general, the damage was not extensive and modern buildings performed well, while some older building suffered severe damage (Source: http://www.caltecheerl.library.caltech.edu/221).

Earthquake: M6.0 September 7, 1999 earthquake in Athens, Greece

On September 7, 1999, a magnitude 6.0 earthquake occurred in the vicinity of Athens, the capital of Greece. The earthquake caused the collapse of 65 buildings, all but a few residential, killing 143 people and injuring approximately 7000. More than 70000 families became homeless. The most extensive and severe damage occurred in the northwestern suburbs of Athens (approximately 1000000 inhabitants), located near the epicenter. The dominant construction types in these areas are reinforced concrete frames and one or two-story buildings with masonry walls. Most of the structures were built according to the (now obsolete) 1959 Greek Seismic Code and a significant number of building, mainly residential, were built illegally, without any seismic provisions. A preliminary estimate of damage was at 655 million USD. This earthquake was felt in much of central Greece and as far as Izmir, Turkey (Source: USGS – http://earthquake.usgs.gov/earthquakes/world).

5. Discussion

One of the major targets of the Disaster Risk Reduction Program through the Hyogo Declaration is to achieve national participation and sub-regional, regional and international cooperation for natural disaster reduction. This is critical for the implementation of the objectives of the International Strategy for Disaster Reduction (ISDR). Unfortunately, few countries from the Balkan region participated with the National Platforms in Disaster Risk Reduction – Bulgaria, Croatia and Macedonia.

The overview of losses from earthquakes in the Balkan region shows only rough statistics and significant uncertainties in the estimates of the number of human victims and total material damages caused by earthquakes. Based on the incomplete data, it is very difficult to draw conclusions regarding the real risks from the earthquakes in some of the Balkan countries and the entire region. Considering that the primary goal of the Disaster Reduction Program is prevention, one of the objectives within the Hyogo Framework for Action Plan 2005–2015 was the establishment of the risks from natural hazards through the PreventionWeb program (http://www.preventionweb.net). This database allows us to obtain data on risk profiles for each country based on the data analysis from EM-DAT (The OFDA/CRED International Disaster Database)

Table 5. Earthquake risk profile by country in the Balkan region, 1980–2010 (Source: PreventionWeb, http://www.preventionweb.net).

		Human exposure*						Economic exposure**		Vulnerability and Risk***			
			% of population exposed to earthquake intensity (modified Mercalli scale classes)						% of GDP exposed to earthquake intensity (modified Mercalli scale classes)				
Country	No. of events	Population exposed	V&VI	VII	VIII	IX–XII	Country ranking (population)	GDP exposed, billions USD	V&VI	Country ranking (GDP)	Vulnerability index	Absolute risk	Relative risk	Mortality risk index
Albania	4	213253	5.86				43/153	3.15	5	52/153	100	30–100	3–10	Medium high
BIH	1	134434	3.39				49/153	2.31	3	56/153	1	0.3–1	0.03–0.1	Very low
Bulgaria	3	25077	0.33				90/153	0.62	-	82/153	1	>0–0.3	0	Negligible
Croatia	1	57890	1.27				69/153	3.37	1	51/153	10	0.3–1	0.1–0.3	Low
Greece	20	1076137	8.99	0.57			24/153	168.26	10	6/153	10	10–30	1–3	Medium
Macedonia	1	100260	4.92				59/153	2.22	5	57/153	0.3	>0–0.3	>0–0.03	Negligible
Montenegro		34829	4.95	0.38	0.39	0.11	80/153	0.58	4	83/153	1	>0–0.3	0.03–0.1	Very low
Romania	3	1087079	4.32	0.57	0.19		23/153	29.08	4	19/153	300	300–1000	10–30	Very High
Serbia	1	170713	1.70	0.03			47/153	2.06	1	58/153	30	10–30	1–3	Medium
Slovenia	1	67745	3.37				65/153	8.94	3	37/153	1	>0–0.3	0.03–0.1	Negligible

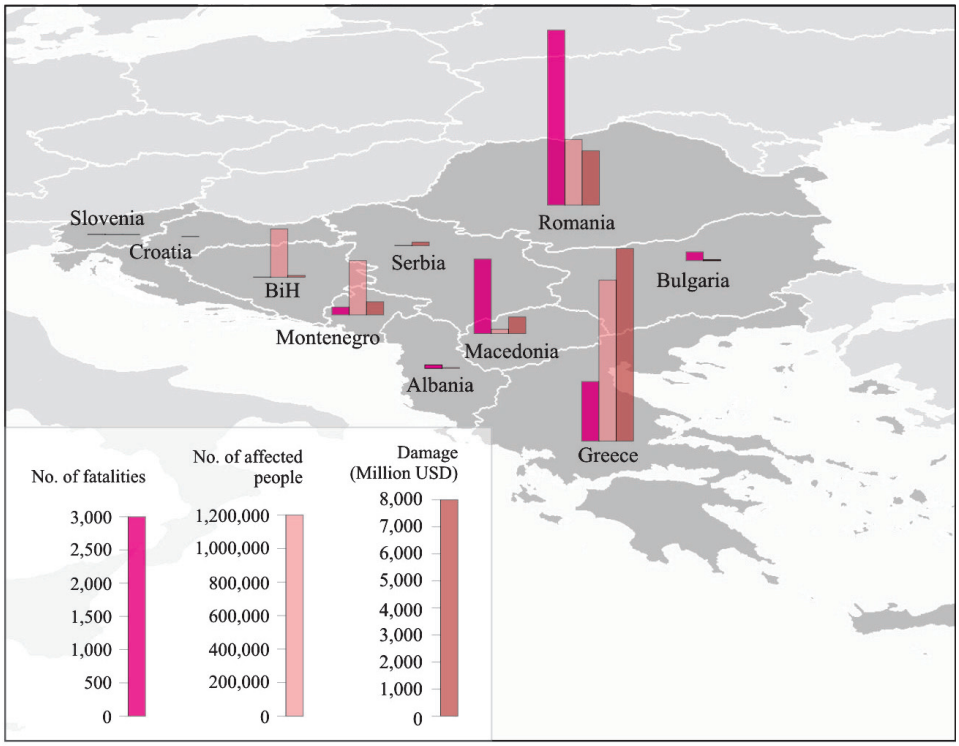
* Modeled number of people present in hazard zones that are subject to potential losses

** Modeled percentage of GDP (Gross Domestic Product) present in hazard zones that are subject to potential losses

*** The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard

Vulnerability index: Estimated number of people killed per year (per million, exposed); Absolute risk: Average number killed per year; Relative risk: Number killed per million per year; Mortality risk index: Average of both indicators (RA+RR/2)

for the period from 1980 to 2010. The risk profile for each country contains human exposure, economic exposure, and an estimate of vulnerability and risk based on the events registered in the database (Table 5). Similar to the data from the analysis for 1900–2010, the population exposed to risk from earthquakes is largest in Greece and Romania, as is the exposed GDP (Gross Domestic Product). Both countries are ranked highly globally based on the exposure of popu-



	No. of fatalities	No.of affected people	Damage (million USD)
Serbia	3	32,230	132.26
Croatia	0	2,000	0
Slovenia	9	1,425	10
Bosnia and Herzegovina	15	286,160	50
Macedonia	1119	26,769	620
Montenegro	122	325,210	488.6
Greece	896	960,398	7,099,3
Romania	2632	393,350	2,010
Bulgaria	131	3,752	0
Albania	47	8,429	0
Total	**4974**	**2,039,723**	**10,410.16**

Figure 3. Losses due to historical earthquakes in the Balkan region for 1900–2010. Source: EM-DAT: The OFDA/CRED International Disaster Database (Université Catholique de Louvain, Brussels, Belgium).

lation and GDP (country ranking). As in the analysis for 1900–2010, the analysis from the PreventionWeb contains significant uncertainties due to a small amount of data for certain countries – either due to the lack of the earthquakes or a lack of data available from national agencies. Apart from that, the 30-year period is too short to analyze the real risk profile for some countries, such as Bulgaria and Macedonia, where earthquakes occur relatively rarely, but those that do occur are of great magnitudes.

Due to the uneven parameters and incompleteness of national data, a lot of data on the strongest earthquakes with the most catastrophic impacts in the Balkan region are completely missing, particularly from the beginning of the 20th century. For instance, there are data missing for the 1904 earthquake in Simitli, Bulgaria (Bayliss and Barton, 2007; Meyer et al., 2007), the 1922 earthquake in Lazarevac, Serbia (unpublished data), the 1904 Pehchevo, Macedonia earthquake and the 1931 earthquake in Valandovo (Jovanovski and Lazarov, 2009). For this reason, it is unrealistic that the Mortality Risk Index for Bulgaria and Macedonia is "negligible" (Table 5).

EM-DAT database analysis for 1900–2010 gives more realistic data on the per-country risk from earthquakes for the Balkan region. When we compare national profiles, it is clear that Romania, Macedonia and Greece are the countries with the highest degree of overall risk (Figure 3). Historically catastrophic earthquakes in relation to the number of casualties have occurred in large urban areas (Thessaloniki, Athens, Bucharest, Skopje, Banja Luka), which also had the highest concentration of material goods and earthquakes of magnitude greater than 6.0. At the same time, these are also the zones of the highest risks from the effects of the earthquakes in the Balkan region based on the analyzed historical data.

6. Concluding remarks

Analysis of the data collected through publicly available databases and other sources regarding the earthquakes and their impact on property and populations in the Balkan region has been performed for 1900 to the present. The analysis was based on available selected data sets, i.e., those registered data from global database EM-DAT. Unfortunately, data from many local or regional databases could not be used, either due to their incompleteness or their unavailability on the webpages of national institutions of the countries included in the analysis.

The analysis has shown that a significant number of people died or were affected by earthquakes in the Balkan region, and that the region suffered significant material losses. Furthermore, the analysis of individual earthquakes and their impact has also shown that many analyzed data have been registered as separate events in certain countries, even though they were caused by a single earthquake.

Data analysis included a relatively long time period of 110 years and, for the first time, consolidated information about the effects of earthquakes on the population (human exposure), through the number killed and affected, as well as information on material damages for the Balkan region. Unfortunately, analysis of data from various sources points to a lack of a large amount of data, as well as the inconsistency of the data regarding individual historically recorded catastrophic earthquakes prior to 1950. For certain countries, data are entirely omitted for some time periods, as is data for individual events, which does not indicate that they did not occur, but that they were not properly recorded. All of this has caused the assessment of risk to population and material goods for the countries with incomplete data to be unrealistic, which limits the possibility of the assessment of their level of risk and total risk.

The open field for future work is primarily the harmonization of the methods of recording data on the effects of earthquakes on the population and material goods, as well systematic recording of data by the national and/or regional institutions. National and regional connections and the exchange of information, as well as the public availability of data, would enable more realistic risk assessment and management from earthquakes as natural hazards for the Balkan region.

References

Abolmasov, B., Mihalić S., Hadži-Niković, G., Marjanović, M. and Krkač, M. (2010): Socio-economic influence of natural disasters in the Western Balkan countries, *Scientific Annals*, School of Geology, Aristotle University of Thessaloniki, in *Proceedings of the XIX CBGA Congress*, Special Volume **100**, Thessaloniki, Greece, September, 23–26, 2010, edited by Christofides, G., Kantiranis, N., Kostopoulos, D. S. and Chatzipetros, A. A., 1–5, ISBN 978-960-9502-02-3.

Albini, P. (2004): A survey of the past earthquakes in the Eastern Adriatic (14th to early 19th century), *Ann. Geophys-Italy*, **47**, 675–703.

Albini, P. and Stucchi, M. (1997): A basic European earthquake catalogue and a database for the evaluation of long-term seismicity and seismic hazard (BEECD), in *Seismic risk in the European Union*, edited by Ghazi, A. and Yeroyanni, M., Brussel-Luxembourg, **1**, 53–77.

Alcantara-Ayala, I. (2002): Geomorphology, natural hazards, vulnerability and prevention of natural disasters in developing countries, *Geomorphology*, **47**, 107–124.

Ambraseys, N. N., Jackson, J. A. and Melville, C. P. (2002): Historical seismicity and tectonics: The case of the Eastern Mediterranean and the Middle East, in *International Handbook of Earthquake and Engineering Seismology,* edited by Lee, W. H. K., Kanamori, H., Jennings, P. C. and Kisslinger, C., Academic Press, Elsevier, 747–763.

Bayliss, T. J. and Burton, P. W. (2007): A new earthquake catalogue for Bulgaria and the conterminous Balkan high hazard region, *Nat. Hazard. Earth Sys.*, **7**, 345–359.

Burton, P. W., Xu, Y., Qin, C., Tselentis, G. and Sokos, E. (2004): A catalogue of seismicity of Greece and the adjacent areas for the twentieth century, *Tectonophysics*, **390**, 117–127.

Caltech Earthquake Engineering Research Laboratory – Caltech Library System Digital Library, California Institute of Technology, accessed April, 2011, http://caltecheerl.library.caltech.edu/221/

EM-DAT: The OFDA/CRED International disaster database, Université Catholique de Louvain, Brussels (Belgium), accessed January, 2011, www.emdat.be

Guha-Sapir, D. (2008): EM-DAT's new disaster classification, in *Disaster data: A balanced perspective*, CRED CRUNCH News, Issue No 13. Centre for Research on the Epidemiology of Disasters. Brussels, Belgium., accessed September 25, 2010, http://www.emdat.be/publications/

Herak, M., Herak, D. and Markušić, S. (1996): Revision of the earthquake catalogue and seismicity of Croatia, 1908–1992, *Terra Nova*, **8**, 86–94.

Meyer, B., Sebrier, M. and Dimitrov, D. (2007): Rare destructive earthquakes in Europe: The 1904 Bulgaria event case, *Earth Planet. Sc. Lett.*, **253**, 485–496.

Milutinović, Z. V. (2007): Urbanistic aspects of post earthquake reconstruction and renewal – experiences of Skopje following earthquake of July 26, 1963, *International Earthquake Symposium*, October 22–26, 2007, Kocaeli, 645–649.

Papazachos, B. and Papazachou, K. (1989): *The earthquakes of Greece*. Ziti Publ., Thessaloniki, 356 pp.

Papazachos, B. and Papazachou, K. (1997): *The earthquakes of Greece*. Ziti Editions, Thessaloniki, 304 pp.

PreventionWeb: Serving the information need of the disaster reduction community, accessed April, 2011, http://www.preventionweb.net

Rodriguez, J., Vos, F., Below, R. and Guha-Sapir, D. (2009): *Annual disaster statistical review 2008 – The numbers and trends*. Centre for Research on the Epidemiology of Disasters. Brussels, Belgium. Jaoffset Printers, Melin, Belgium. 25 pp.

Shebalin, N. V., Karnik, V. and Hadžievski, D. (editors) (1974): *Catalogue of earthquakes. Part I, 1901–1970, Part II, prior to 1901, Part III, Atlas of isoseismal maps*. UNDP/UNESCO Survey of the seismicity of the Balkan region, Skopje.

Sović, I. (1999). Croatian macroseismic database, *Phys. Chem. Earth A*, **24**, 501–503.

Sulstarova, A. and Kociu, S. (1975): *The catalogue of Albanian earthquakes*. Botim i Qendres Sizmologjike, Tirana, Albania, 223 pp.

UN: International Strategy for Disaster Reduction Programme 2005–2015, UNISDR, accessed April, 2011, www.unisdr.org

UNESCO (1984): Montenegro earthquake. The conservation of the historic monuments and art treasures, United Nations Educational, Scientific and Cultural Organization, Paris, accessed April, 2011, 50 pp, http://unesdoc.unesco.org/images/0014/001472/147207eo.pdf

USGS: World earthquake information by country/region – United State Geological Survey, accessed January, 2011, http://earthquake.usgs.gov/earthquakes/world/

Utsu, T. (2002): A list of deadly earthquakes in the world: 1500–2000, in *International Handbook of Earthquake and Engineering Seismology,* edited by Lee, W. H. K., Kanamori, H., Jennings, P. C. and Kisslinger, C., Academic Press, Elsevier, 691–717.

SAŽETAK

Gubici uslijed povijesnih potresa na području Balkana: Pregled javno dostupnih podataka

Biljana Abolmasov, Milorad Jovanovski, Pavle Ferić i Snježana Mihalić

U radu se analiziraju gubitci uslijed katastrofalnih potresa u Balkanskoj regiji na temelju podataka o broju stradalih i materijalnoj šteti, a koji su prikupljeni iz OFDA/CRED Međunarodne baze podataka o katastrofama (Université Catholique de

Louvain, Brussels, Belgium) za razdoblje od 1900. do 2010. Katastrofalne gubitke prouzročilo je 62 potresa u sljedećim državama u regiji: Sloveniji, Hrvatskoj, Bosni i Hercegovini, Crnoj Gori, Albaniji, Srbiji, Rumunjskoj, Bugarskoj, Makedoniji i Grčkoj. Analiza je pokazala da je u cijeloj regiji tijekom razmatranog razdoblja smrtno stradalo 4974 ljudi, 2033723 ljudi je zahvaćeno posljedicama potresa, dok je ukupna materijalna šteta iznosila 10410,16 milijuna USD. Kao glavni nedostatak javno dostupnih izvora podataka o potresima ističe se nekonzistentnost podataka o štetama nastalim uslijed potresa. U radu se također daje sažeti prikaz zapisa o najkatastrofalnijim potresima koji su se dogodili u posljednjih 110 godina, a na osnovi podataka iz drugih javno dostupnih baza podataka.

Ključne riječi: Balkanska regija, katastrofalni potresi, baze podataka o prirodnim katastrofama

Corresponding author's address: Biljana Abolmasov, Faculty of Mining and Geology, University of Belgrade, Djušina 7, 11000 Belgrade, Serbia, e-mail: biljana@rgf.bg.ac.rs