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EGE VE AKDENİZ BÖLGELERİNDE DEPREMSELLİĞİN İNCELENMESİ
AN INVESTIGATION OF SEISMICITY FOR THE AEGEAN AND MEDITERRANEAN REGIONS

Nilgün Sayıl

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Anahtar Kelimeler: Ege ve Akdeniz Bölgeleri, Depremsellik, Tekrarlanma peryodu, Poisson model

ÖZ 35°-39°N, 26°-38°E koordinatlarıyla sınırlandırılmış Ege ve Akdeniz bölgelerinin depremselliğini araştırmak için Gutenberg-Richter magnitüd-frekans ilişkisi, sismik risk ve tekrarlanma peryodu hesaplanmıştır. Çözümlemede 1900 öncesi tarihsel dönem ($I_0 \geq 5.0$ şiddet değerleri $M_S \geq 4.4$ magnitüdlerine karşılık gelmektedir) ve 2007'ye kadar olan aletsel dönem ($M_S \geq 4.0$) deprem verileri kullanılmıştır. İnceleme alanı bölgenin sismotektonik özellikleri, levha tektoniği modelleri ve jeolojisi dikkate alınarak 15 alt-bölgeye ayrılmıştır ve tüm hesaplamalar bu alt-bölgeler için ayrı ayrı yapılmıştır. Elde edilen sonuçlara gore, hesaplanan magnitüd-frekans ilişkisindeki a ve b değerleri 3.10±0.24-5.29±0.52 and 0.39±0.03-0.73±0.08 aralığında bulunmuştur. En yüksek b değerleri 7. (Gökova Körfezi-Muğla-Gölhisar) ve 1. (İzmir-Sakız adası) alt-bölgeler için, en düşük b-değerleri ise 15. (Antakya) ve 8. (Bodrum-İstanköy) alt-bölgeler için bulunmuştur. Son olarak a ve b değerlerinden yararlanarak yapılan sismik risk ve tekrarlanma peryodları hesaplamaları en yüksek risklerin ve en kısa tekrarlanma peryodlarının en düşük b değerlerine sahip 15 ve 8.alt-bölgelerde olduğunu göstermiştir.

Key Words: *Aegean and Mediteranean Regions, Seismicity, Recurrence period, Poisson model*

ABSTRACT *In order to investigate the seismicity of Aegean and Mediterranean regions limited with the coordinates of 35°-39°N, 26°-38°E, Gutenberg-Richter magnitude-frequency relation, seismic risk and recurrence period have been computed. The data belonging to both the historical period before 1900 ($I_0 \geq 5.0$ corresponding to $M_S \geq 4.4$) and the instrumental period until 2007 ($M_S \geq 4.0$) has been used in the analysis. The study area has been divided into 15 sub-regions due to certain seismotectonic characteristics, plate tectonic models and geology of the region. All the computations have been performed for these sub-regions, separately. According to the results, a and b values in the computed magnitude-frequency relations are in the intervals 3.10±0.24-5.29±0.52 and 0.39±0.03-0.73±0.08, respectively. The highest b values have been determined for sub-regions 7 (Gökova Gulf-Muğla-Gölhisar) and 1 (Izmir- Sakız Island). The lowest b values have also been determined for sub-regions 15 and 8 (Antakya and Bodrum-İstanköy). Finally, seismic risk and recurrence period computations from a and b values have shown as expected that sub-regions 15 and 8 which have the lowest b values and the highest risks and the shortest-recurrence periods.*

INTRODUCTION

Anatolia and its neighbourhood are located in the most active section of the Alpine-Himalayan Belt in the eastern Mediterranean and include most important tectonic structures. Therefore Anatolia has been exposed to strong earthquakes along the history. The subject of this study is to estimate the probability of earthquake occurrences and recurrence periods by using Poisson model from historical and instrumental data for selected characteristic sub-regions in Aegean and Mediterranean regions.

THEORY (and method)

In the investigation of earthquake occurrence frequencies, it seems that they exhibit usually a linear relation. An equation to represent the relation between the magnitude and earthquake occurrence frequencies has been suggested by Gutenberg and Richter (1954). The general form of this well-known equation (1) is:

$$\mathrm{LogN}(M) = a - bM \tag{1}$$

where N(M) (cumulative frequency), is the number of earthquakes equal or larger than M magnitude. For (M, LogN) dataset, a and b-values are commonly computed by using the linear least square approximation in Eq. (2);

$$\sum_{i=1}^{n} \mathrm{LogN}_i = an - b\sum_{i=1}^{n} M_i\,, \qquad \sum_{i=1}^{n} M_i.\mathrm{LogN}_i = a\sum_{i=1}^{n} M_i - b\sum_{i=1}^{n} M_i^2\,, \tag{2}$$

$$a' = a - \mathrm{Log}(b\ln 10)\,; \quad a_1' = a' - \mathrm{Log}T_1 \quad ; \quad n(M) = 10^{a_1' - bM} \quad ; \quad R(M) = 1 - e^{-n(M)T}\,; \quad Q = \frac{1}{n(M)} \tag{3}$$

where n is the number of group. The annual mean number n of earthquakes ($M \geq M_1$) with specific magnitude equal and larger than M_1 value in a specific time can be estimated by using these relations. In any regions, occurrence risk in T years of an earthquake with any magnitude M for observation interval of T_1 year is calculated by R(M) in Eq. (3) and recurrence period of an earthquake is estimated by Q in Eq. (3) (Tabban and Gencoğlu, 1975).

Analysis for Aegean and Mediterranean Regions

In this study, the linear least square method (Eq. (2)) has been applied to obtain a and b parameters in Eq. (1) for each sub-region shown in Fig. 1 using the earthquakes of $M_S \geq 4.0$ occurred from BC-496 to 2007. Distribution of the earthquakes with the magnitude increment of 0.5 and cumulative frequency values for each sub-region have been given in Table 1. Fig. 2 shows the magnitude-frequency relations. Seismic risk and recurrence period values have been estimated by using a and b parameters given in Table 2. In the computations, magnitudes of $M_S \geq 5.0$ and increment interval of 0.5 were chosen, and the relations in Eq. (3) for seismic risk and recurrence period are used. Observational time interval (T_1 year) has been determined by the completeness condition of each sub-region. Maximum magnitude value (M_{max}) has been selected as magnitude of the biggest earthquake for each sub-region. Computations have been done for decades in the next 100 years in each sub-region. The results for sub-regions with lowest and highest b-values have only been shown in Table 3 for projection. The standardized residuals of the predicted seismic risk values have been determined.

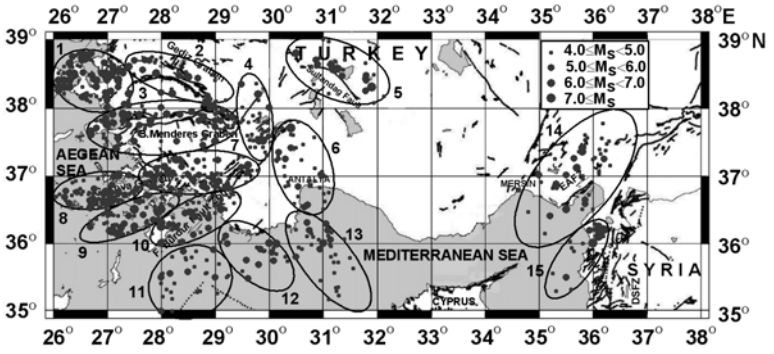

Figure-1 Epicentral map and selected 15 sub-regions of Aegean and Mediterranean regions.

Table-1. Cumulative frequencies (N_i) with the magnitude increment of 0.5 for the earthquakes occurred in each sub-region

Magnitudes	Cumulative frequencies (N_i) for each sub-region														
(M_S)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4.0-4.4	142	27	100	65	31	46	106	84	66	69	39	24	35	42	21
4.5-4.9	113	14	65	29	20	19	58	43	30	33	22	12	15	26	10
5.0-5.4	88	11	46	7	15	8	35	31	20	17	12	10	8	11	6
5.5-5.9	39	4	18	3	5	2	4	6	11	9	3	3	4	9	5
6.0-6.4	24	2	11	1	4	1	3	4	6	4	0	2	1	3	3
6.5-6.9	10	2	6	0	2	1	1	3	3	4	0	1	0	0	3
7.0.7.4	0	0	1	0	1	1	0	2	0	1	0	0	0	0	3
7.5-7.9	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1

Table-2. a and b-values with a standard errors estimated by the linear least square method for each sub-region

Sub-Regions	Completeness date (d/m/yr)	Earthquake number	a	b
1 İzmir-Sakız Island	01.01.1639	142	5.29±0.52	0.66±0.09
2 Manisa-Salihli	23.02.1652	27	3.19±0.24	0.45±0.04
3 Sisam Is.-Aydın-Denizli	07.06.1751	100	4.74±0.32	0.63±0.05
4 Dinar-Çivril	04.10.1914	65	3.84±0.57	0.63±0.09
5 Bolvadin-Afyonkarahisar	16.10.1862	31	3.48±0.19	0.48±0.03
6 Antalya Gulf	03.10.1914	46	3.50±0.55	0.55±0.09
7 Gökova Gulf-Muğla-Gölhisar	24.08.1920	106	4.73±0.51	0.73±0.08
8 Bodrum-İstanköy	27.08.1886	84	3.30±0.37	0.43±0.06
9 Bozburun-Sombeki Island	18.10.1844	66	4.10±0.17	0.54±0.02
10 Fethiye-Rodos Island	28.02.1852	69	4.06±0.21	0.55±0.03
11 west of the Cyprus Arc	04.04.1925	39	3.62±0.51	0.55±0.08
12 Kaş-Finike Gulf	30.04.1912	24	3.11±0.31	0.46±0.05
13 Kumluca- Kırlangıç offshore	05.06.1927	35	3.36±0.44	0.53±0.07
14 İskenderun Gulf-Andırın	17.02.1908	42	3.81±0.31	0.54±0.05
15 Antakya	13.08.1822	21	3.10±0.24	0.39±0.03

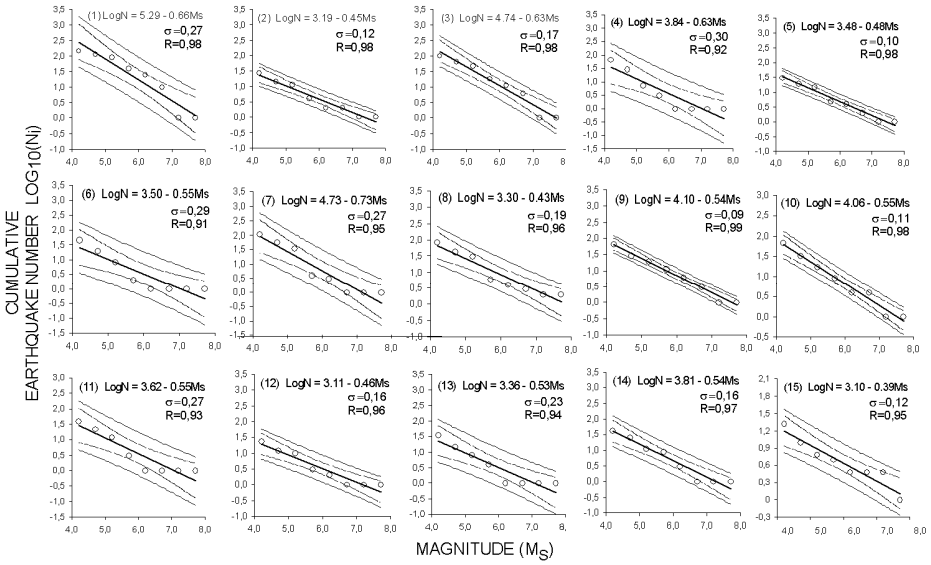

Figure-2. Magnitude-frequency relations computed by the linear least square method. Thick line shows the estimated relation. Broken and thin lines show confidence interval

band of %95 and prediction interval band. σ and R are standard deviation and correlation coefficient, respectively.

Table-3. Seismic risk and recurrence period values estimated by using a and b-values for the earthquakes of $5.0 \leq M_S \leq M_{max}$ with the magnitude increment of 0.5 in observation interval (T_1 year) of each sub-region. Maximum magnitude value (M_{max}) is magnitude of the biggest earthquake for each sub-region.

Sub-regions	Magnitudes (M_S)	Seismic risk R(M)% Period (year) 10	20	30	40	50	60	70	80	90	100	Recur. period Q (year)
1(T_1=369 yr)	5.0	82.5	96.9	99.5	99.9	100	100	100	100	100	100	5
M_{max}=6.8	5.5	55.7	80.4	91.3	96.2	98.3	99.2	99.7	99.9	99.9	100	10
	6.0	31.7	53.4	68.1	78.2	85.1	89.8	93.1	95.3	96.8	97.8	20
	6.5	16.3	30.0	41.4	51.0	59.0	65.7	71.3	76.0	79.9	83.2	40
7(T_1=88 yr)	5.0	55.6	80.3	91.3	96.1	98.3	99.2	99.7	99.9	99.9	100	3
M_{max}=6.5	5.5	29.6	50.4	65.1	75.4	82.7	87.8	91.4	94.0	95.7	97.0	21
	6.0	14.0	26.1	36.5	45.4	53.1	59.7	65.3	70.2	74.4	78.0	25
	6.5	6.3	12.2	17.8	23.0	27.9	32.4	36.7	40.7	44.4	48.0	79
8(T_1=122 yr)	5.0	68.9	90.4	97.0	99.1	99.7	99.9	100	100	100	100	4
M_{max}=7.6	5.5	51.0	76.0	88.2	94.2	97.2	98.6	99.3	99.7	99.8	99.9	20
	6.0	35.2	58.1	72.8	82.4	88.6	92.6	95.2	96.9	98.0	98.7	30
	6.5	23.3	41.1	54.8	65.3	73.4	79.6	84.3	88.0	90.8	92.9	38
	7.0	14.9	27.6	38.4	47.6	55.4	62.0	67.7	72.5	76.6	80.1	60
	7.5	9.4	17.9	25.6	32.5	38.9	44.6	49.8	54.5	58.8	62.6	85
15(T_1=186yr)	5.0	57.1	81.6	92.1	96.6	98.5	99.4	99.7	99.9	100	100	30
M_{max}=7.5	5.5	41.7	66.0	80.2	88.5	93.3	96.1	97.7	98.7	99.2	99.5	35
	6.0	29.1	49.8	64.4	74.8	82.1	87.3	91.0	93.6	95.5	96.8	55
	6.5	19.7	35.6	48.3	58.5	66.7	73.3	78.5	82.8	86.2	88.9	60
	7.0	13.1	24.5	34.4	43.0	50.4	56.9	62.6	67.5	71.7	75.4	62
	7.5	8.6	16.4	23.6	30.1	36.1	41.6	46.6	51.2	55.3	59.2	180

CONCLUSIONS

In this study, seismicity of Aegean and Mediterranean regions has been investigated by means of computations of the magnitude-frequency relation, seismic risk and recurrence period, and the results tried to be interpreted and related with the active tectonic of region. In twos of the highest and lowest b-values were determined as 0.73±0.08, 0.66±0.09 for sub-regions 7, 1, and as 0.39±0.03, 0.43±0.06 for sub-regions 15, 8, respectively. As it well known, the high b value implies that the high seismic activity had rolled in that region. According to the seismic risk estimations, the highest earthquake occurrence probability of $M_S \geq 7.0$ in the next 100 years is %80.1 (σ=0.19, R=0.89) for sub-region 8 and %75.4 (σ=0.15, R=0.92) for sub-region 15. Recurrence times for the earthquakes with the same magnitude have been found as 60 and 62 years in these sub-regions. The highest occurrence probability and recurrence time of an earthquake with $M_S \geq 7.5$ in the next 100 years have been found as %62.6 (σ=0.19, R=0.89) and 85 years for sub-region 8, respectively. Sayıl and Osmanşahin (2005) had applied the regional time- and magnitude-predictable model at the same sub-regions of western Anatolia by using earthquakes with the magnitude $M_S \geq 5.5$ to compute the occurrence probabilities and the recurrence intervals of large earthquakes. The conclusions of present study agree with the results of the regional time- and magnitude-predictable model.

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