7. *A Statistical Investigation of Conspicuous Earthquakes in Japan during the Period 1933–1943.*

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1. One of the writers had made investigations on earthquakes felt at Tokyo, and the result was published in the former number of this publication.[1] We extended the investigation to conspicuous earthquakes in Japan. The seismic activity in Japan had generally been discussed so far only from data of disastrous earthquakes. But we studied it from data obtained with seismographs.

Earthquakes are classified by magnitude by the Central Meteorological Observatory of Japan in three according to the radius r of the felt area: *Remarkable earthquake* $r>300$ km.; *Moderate earthquake* $300>r>200$ km.; *Earthquake of small felt area,* $200>r>100$ km.

Neglecting the focal depth, the coordinates, time of occurrence, and class of the magnitude of the earthquakes were tabulated. Next, the difference of the time of occurrence and the distance between earthquakes which occurred in succession were entered on the table. The above-mentioned data were made use of in the following investigations.

2. Bearing and distance of the epicentres of successive earthquakes were plotted in turn as shown in Fig. 1. It may be only too natural that the bearing conformed to that of the length of the Japan Islands.

3. The frequency-distribution of the monthly numbers of earthquakes was examined with χ^2 -test to make clear which formula of distribution, Gauss's or Poisson's, fits better to the obeserved frequencies. The observed and the two calculated frequency-distributions are shown in Fig. 2. The values of χ^2 for Gaussian and Poisson's distributions were computed at 15.7 and 22.2 respectively. Therefore it may be concluded that the monthly numbers of earthquakes are distributed normally, or distributed uniformly and at random. This result applies to the case of earthquakes felt at Tokyo studied by one of the writers.

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1) F. KISHINOUYE, *Bull. Earthq. Res. Inst.*, 26 (1949), 73.

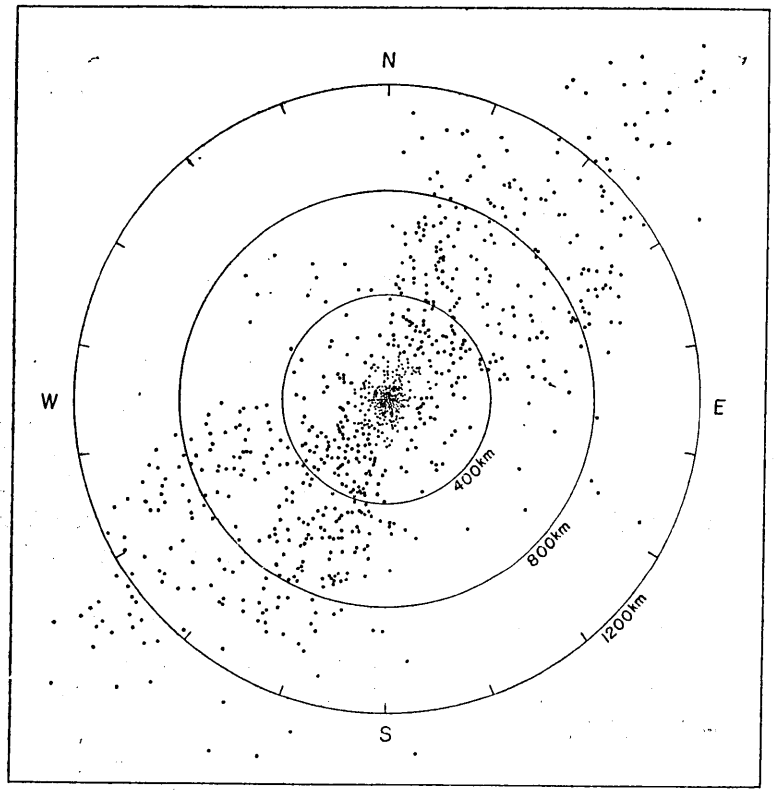

Fig. 1. Position of successive earthquakes.

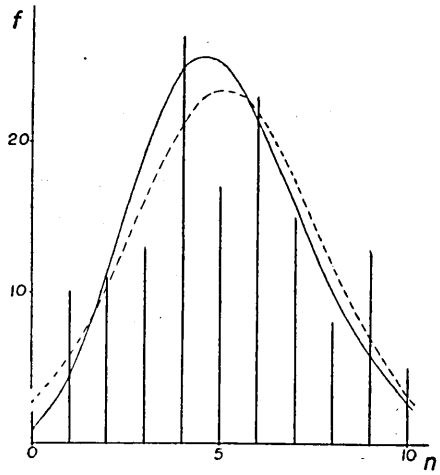

Fig. 2. Frequency-distribution of monthly number of earthquakes. (Full line: Gaussian distribution, dotted line: Poisson's distribution.)

4. The following table shows the relation of yearly numbers and the class of magnitudes of conspicuous earthquakes in Japan during 1933-1943. The χ^2 -test was applied to the table, and the value of χ^2 was computed at

Table I.

Magnitude \ Year	1933	'34	'35	'36	'37	'38	'39	'40	'41	'42	'43	Total
Remarkable	50	10	17	13	15	31	12	9	10	12	23	202
Moderate	40	12	23	11	21	36	17	15	22	18	22	239
Small Area	91	57	75	48	50	95	60	43	42	41	105	707
Total	181	79	115	72	86	162	89	67	74	71	150	1146

33.3. The yearly number and magnitude proved to be not non-correlative, but from the data which are omitted here it became obvious that the monthly numbers were not correlative to the occurrence of remarkable earthquakes.

5. Relation between the distance and time interval of each succeeding earthquake is shown in Table II.

Table II.

Distance \ Number of earthq.	0-1	2-3	4-5	6-7	8-9	10-20	Total
0-200 km	260	58	29	20	14	28	409
200-400	46	28	29	14	14	26	157
400-600	22	46	19	11	11	26	135
600-800	38	37	13	10	8	12	118
800-1000	30	21	20	12	5	19	107
Total	396	190	110	67	52	111	926

The contingency table was tested by the χ^2-test. Assuming non-correlation between the distance and the time interval, the value of χ^2 was computed at 160, so the distance to the next earthquake would have some relation to the time lag of occurrence.

6. The apparent velocity of propagation of seismic activity, or the ratio of distance to number of days to the next earthquake, was calculated. The mean apparent velocity was obtained as 165 km/day.

7. The difference of times of occurrence of earthquakes was reckoned successively. The relation between the two succeeding time differences in day are shown in Table III.

Table III.

n_1 \ n_2	0-1	2 3	4-5	6-7	8-9	10-50	Total
0-1	222	78	40	16	14	54	424
2-3	69	53	28	25	15	27	217
4-5	45	28	18	14	7	17	129
6-7	23	18	10	8	6	9	74
8-9	21	8	12	2	5	13	61
10-50	41	31	18	11	13	25	139
Total	421	216	126	76	60	145	1044

Regarding the table as a contingency table, the χ^2-test was applied also in this case. The value χ^2 was obtained as 68.1, so the succeeding time intervals of earthquakes were considered to be not mutually independent.

8. The relation between distance and time interval of earthquakes before and those after the *remarkable* earthquakes were studied by the χ^2-test as before. The data are shown in Tables IV and V.

Table IV.

Distance \ Number of earthq.	0-2	3-5	6-8	9-40	Total
0-200 km	44	4	6	6	60
200-400	14	14	9	7	44
400-600	4	8	2	6	20
600-800	7	7	4	5	23
800-1000	7	7	2	6	22
1000-2000	9	8	7	6	30
Total	85	48	30	36	199

The values of χ^2 were obtained as 40.4 and 51.6 respectively. Then there would be some relations between distance and the time differences of earthquakes which occurred before or after the *remarkable* earthquakes.

The frequency of numbers of earthquakes in the above tables (Table II and Fig. 1, Tables IV and V) will be affected by ring-shaped area limited by two distances (in the first column of the tables) which confine the interval. Multiplying the reciprocal numbers proportional to the area to the earthquake

Table V.

Distance \ Number of earthq.	0-2	3-5	6-8	9-29	Total
0-200 km	64	7	6	4	81
200-400	14	5	6	9	34
400-600	8	8	4	5	25
600-800	12	6	3	2	23
800-1000	6	5	4	6	21
1000-2000	4	9	5	6	24
Total	108	40	28	32	208

numbers, we checked the above results. But it was not necessary to change our conclusions.

9. Relation between earthquake numbers of a half-month and those of the next half-month is shown in the following table.

Table VI.

n_1 \ n_2	0-1	2-3	4-5	6-7	8-47	Total
0-1	33	37	13	5	2	90
2-3	37	44	27	11	4	123
4-5	13	27	19	5	7	71
6-7	5	9	7	4	3	28
8-47	2	7	4	3	5	21
Total	90	124	70	28	21	333

The value of χ^2 was obtained as 31.5, so it was concluded that half-monthly numbers of earthquakes are in some correlation to those of the next half-month.

10. Résumé.

Geographical and time distributions of conspicuous earthquakes which occurred in Japan during the period 1933-1943 were statistically investigated, applying χ^2-test. Monthly numbers of earthquakes were considered to be in normal distribution, so the numbers will be treated by the theory of probability, or the monthly numbers may be predicted statistically. It was also concluded that the monthly numbers were not independent of the magnitude of the earthquake.

The cost of this investigation was defrayed from the Scientific Expenditure of the Department of Education.

7. 日本における1933年から1943年までの間に起つた著しい地震の統計的研究

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日本の地震活動については災害をおこした大地震によつて論じたものが多いが，こゝでは地震計によつて觀測された地震について調べた．材料は氣象要覽により，顯著・稍顯著及び小區域地震を採つた．

毎月の頻度は正規分布をなすので確率論で取扱ひ得ることを知り，地震の規模と年頻度とは無關係でないとの結果を得たことは，前に筆者の一人が東京の有感地震を調べた時と同樣の結果である．その他，次の地震までの距離，次の地震の起る迄の日數等について相關表をつくり，χ^2 檢定法を應用して調べた．