

20. *Relation between Earthquakes and Precipitation,  
Barometric Pressure, and Temperature.  
A Supplementary Note.*

By Seiti YAMAGUTI,

Earthquake Research Institute.

(Read Feb. 18, 1936.—Received March 20, 1936.)

**Introduction.**

This investigation was made with the intention of ascertaining whether or not the results obtained in a previous paper<sup>1)</sup> might have any real physical significance beyond the fact that they may by mere chance serve as the meteorological elements on these two sides of the country, namely on the Japan Sea side and on the Pacific side.

For this purpose, meteorological elements in other regions on the Pacific side were taken for argument. First, we took the precipitations, barometric pressure, and temperature, summed over each season and three meteorological stations, Mito, Isinomaki, and Miyako, the three being denoted by Q', B', and T', respectively. Second, we took the same meteorological elements at three stations, Numadu, Hamamatu, and Nagoya, denoted by Q'', B'', and T'', respectively.

The data of earthquakes, that occurred in the Kwantô Districts,

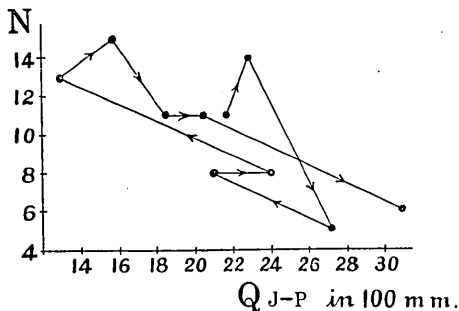


Fig. 1. Number of "felt" earthquakes in Tokyo and Bôsô Hantô, and the differential precipitation in winter.  
J: Japan Sea side.  
P: Pacific side.

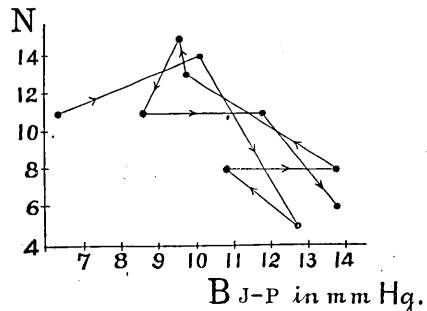


Fig. 2. Number of "felt" earthquakes in Tokyo and Bôsô Hantô, and the differential barometric height in winter.

1) S. YAMAGUTI, *Bull. Earthq. Res. Inst.*, 13 (1935), 569~575.

and which are to be compared with the meteorological elements, are the same as those given in a previous paper. The correlation coefficients between the frequencies of earthquakes and the new meteorological elements were calculated in the same way as before. Three representative diagrams which show the correlations, already cited in a previous paper, are given in Figs. 1, 2, and 3.

The results, which are shown in Table I, II, and III, may, to a certain extent, be considered as verifying the results given in a previous paper.

On the other hand, the probable error corresponding to the correlation coefficient with a value of about 0.5, was calculated and estimated to be 0.10.

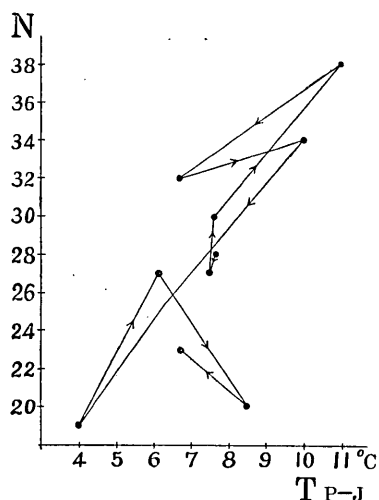


Fig. 3. Number of "felt" earthquakes in Kinugawa, Tonegawa, and Kasumigaura, and the temperature difference in winter.

Table I. Correlation Coefficients between the Precipitations (in 100 mm), and the Earthquakes in Kwantô Districts.

Earthquake regions		"Felt" earthquakes.					"Conspicuous and rather conspicuous".	
		Iwaki Oki Kasima Nada	Tyôsi Oki Sagami Nada	Kinugawa Tonegawa Kasumigaura	Tokyo Bôsô Hantô	Sagami (land) Idu Hantô	Land	Marine
Spring	Q'	-0.41	0.33	0.12	0.07	-0.37	-0.42	0.09
	Q''	0.59	0.34	0.50	-0.04	0.05	-0.20	0.29
	Q'-Q''	-0.75	0.08	-0.21	0.09	-0.37	-0.25	-0.10
Summer	Q'	-0.63	-0.04	0.23	-0.21	0.17	-0.42	-0.09
	Q''	-0.32	-0.17	-0.40	-0.23	-0.17	-0.42	-0.48
	Q'-Q''	-0.03	0.18	0.63	0.13	-0.10	0.23	0.52
Autumn	Q'	-0.43	-0.43	0.27	0.36	0.14	0.14	-0.12
	Q''	-0.17	-0.26	0.12	0.32	-0.05	0.06	-0.26
	Q'-Q''	-0.21	0.01	0.09	-0.23	0.32	0.06	0.43
Winter	Q'	-0.32	-0.30	0.13	0.37	-0.35	0.04	-0.28
	Q''	-0.40	-0.05	0.12	0.18	-0.06	-0.07	-0.06
	Q'-Q''	0.16	-0.20	-0.02	0.11	-0.23	0.10	-0.17

Table II. Correlation Coefficients between the Barometric pressure (in mm. Hg), and the Earthquakes in Kwantô Districts.

Earthquake regions		"Felt" earthquakes.					"Conspicuous and rather conspicuous."	
		Iwaki Oki Kasima Nada	Tyôsi Oki Sagami Nada	Kinugawa Tonegawa Kasumigaura	Tokyo Bôsô Hantô	Sagami (land) Idu Hantô	Land	Marine
Spring	B'	0.47	0.45	0.06	0.05	-0.09	-0.13	0.48
	B''	0.33	0.46	-0.16	0.07	-0.11	-0.18	0.57
	B'-B''	0.54	0.41	0.27	0.02	-0.05	-0.06	0.45
Summer	B'	-0.04	-0.06	-0.27	0.44	0.12	0.25	0.23
	B''	0.19	0.01	-0.03	0.47	0.02	0.38	0.43
	B'-B''	-0.29	-0.08	-0.25	-0.02	0.11	-0.12	-0.20
Autumn	B'	0.13	0.27	-0.32	0.16	0.14	-0.11	-0.31
	B''	0.09	0.45	-0.27	0.22	0.17	-0.07	0.01
	B'-B''	0.17	-0.12	-0.29	0.01	0.04	-0.14	-0.52
Winter	B'	-0.05	0.39	-0.01	0.67	0.35	-0.16	-0.54
	B''	0.04	0.27	0.08	0.64	0.22	-0.16	-0.48
	B'-B''	-0.16	0.46	-0.10	0.57	0.43	-0.13	-0.49

Table III. Correlation Coefficients between the Temperature (in °C), and the Earthquakes in Kwantô Districts.

Earthquake regions		"Felt" earthquakes.					"Conspicuous and rather conspicuous".	
		Iwaki Oki Kasima Nada	Tyôsi Oki Sagami Nada	Kinugawa Tonegawa Kasumigaura	Tokyo Bôsô Hantô	Sagami (land) Idu Hantô	Land	Marine
Spring	T'	0.28	0.64	0.22	0.09	-0.03	-0.39	0.38
	T''	0.62	0.64	0.23	-0.16	-0.08	-0.45	0.60
	T''-T'	0.52	0.05	0.03	-0.37	-0.07	-0.11	0.35
Summer	T'	0.18	0.34	0.24	-0.07	-0.43	-0.10	0.29
	T''	0.43	0.47	0.20	-0.09	-0.55	-0.02	0.13
	T''-T'	0.30	0.04	-0.18	-0.01	0.02	0.18	-0.36
Autumn	T'	0.06	0.21	-0.37	-0.03	-0.33	-0.33	-0.29
	T''	0.30	0.39	-0.68	0.03	-0.51	-0.36	-0.05
	T''-T'	0.32	0.22	-0.39	-0.04	-0.22	0.01	0.38
Winter	T'	0.15	0.22	0.18	0.44	-0.32	-0.14	-0.60
	T''	0.12	0.47	0.19	0.63	-0.15	-0.18	-0.72
	T''-T'	-0.08	0.39	-0.01	0.25	0.58	-0.36	-0.11

### Results and Discussions.

The results of the present study are summarized as follows:

1. For the precipitations.
  - (a). The precipitations on the preceding regions, as cited in a previous paper, were most effective upon occurrence of the earthquakes *in winter*, while those on the present regions, are most effective for the same purpose *in spring and summer*.
  - (b). The former precipitations were most effective on "felt" earthquakes in Tyôsi Oki and Sagami Nada, and the latter most effective on "felt" earthquakes in Iwaki Oki and Kasima Nada.
2. For the barometric pressure.
  - (a). The barometric pressure on the former regions as well as on the present regions are in closer relations *in winter and spring*, with the occurrence of the earthquakes.
  - (b). The barometric pressures in all regions in common are closely related to the occurrence of the "conspicuous and rather conspicuous" earthquakes in *marine* and not in *land* areas. They are also related, in common, to the occurrences of "felt" earthquakes in Tyôsi Oki and Sagami Nada as well as in Tokyo and Bôsô Hantô.
3. For the temperature.
  - (a). The temperatures in the previous regions were effective in *autumn and winter* upon the occurrence of earthquakes, while those in the present regions are effective in *winter and spring*.
  - (b). The temperatures in the present regions are effective upon the "felt" earthquakes in Tyôsi Oki and Sagami Nada, as well as in Sagami (land) and Idu Hantô, in which respects it is quite similar to that in the previous study.
4. The values of the correlation coefficients vary with the earthquake regions. It is interesting to find the existence of certain definite earthquake regions that have comparatively great correlation coefficients in their meteorological elements.
5. Precipitation, barometric pressure, and temperature govern the occurrence of earthquakes in different ways according to season and with regard to the particular earthquake region. They are by no means so simple as may be expected to exist some parallelism among the above three meteorological elements.
6. The result of the investigation on "Earthquakes and Rainfall"

made by Mr. J. F. Brennan<sup>2)</sup> in Jamaica, has shown the correlation between them to be negative, with the results of my investigations, in the case of the correlation between the "felt" earthquakes in Kwantô Districts and the winter precipitation on the Japan Sea side, showing fair agreement with his, although the methods of the two investigators differ.

## 20. 地震と雨雪量, 氣壓, 及氣温との關係 (補遺)

地震研究所 山口 生 知

此の研究は前の研究の結果が、實際の物理的意味を有するか、或は偶然起り得るものかごうかを確かめる目的でなされた。

此の爲に先づ水戸、石巻、及宮古に於ける雨雪量、氣壓、及氣温を採り、次いで沼津、濱松、及名古屋に於ける同様の氣象要素を採り、之等と關東地方に起つた地震との間の相關係數を、前論文と全く同様の方法で計算して見た。

其の結果は第 I 表、第 II 表、及第 III 表に示される通りであつて、前論文の結果を或る程度まで證明するものと考へられる。

即ち之を綜合すれば、次の通りである。

1. 前論文に掲げられて居る地方の雨雪量は關東地方の地震と冬季に於いて、最も關係が深かつたが今回の地方に於けるものは春及夏に於いて最も關係が深い様に見受けられる。又前回の雨雪量は銚子沖及相模灣の有感地震に最も影響があつたが、今回の雨雪量は磐城沖及鹿島灘の有感地震に影響が多い。
2. 氣壓は前回は今回も同様に冬及春に於いて關東地方の地震と最も密接な關係がある。又凡ての地方に於ける氣壓は、關東地方の海底に起る顯著及稍々顯著地震と最も密接な關係があるが之に反して陸上に起る同上の地震とは餘り密接な關係が無い。
3. 前回の地方の氣温は秋及冬關東地方の地震發生に影響を及ぼして居るが、今回の地方に於けるものは冬及春に於いて影響が多い。前回は今回も全く同様に銚子沖及相模灘並に相模及伊豆半島の地震に影響が多い。
4. 相關係數の値は、地震の起る地方別に依つて變化して居る、而して大なる相關係數を有する或る特定の地震地方が存在すると云ふことは面白いことと思ふ。
5. 雨雪量、氣壓、及氣温の三つの間には密接な關係があつて、其の中の一つと地震との間の關係を研究すればそれで足ると考へられる向もあるが、實際問題としては決して左様に簡單では無い。
6. 大森先生や寺田先生方の古い時代の研究の結果に於いても、雨雪量と地震の間には可成密接な關係があること云ふことになつて居り、又 J. F. Brennan 氏が中米の Jamaica に於いて研究された結果に於いても、負の相關係があること云ふことを報告して居る(私の研究に於いて、日本海方面の冬季の雨雪量と關東地方の有感地震との間の關係に相當する。)ことは雨雪量と地震との間の相關係存在の意味を強めるものと思はれる。

2) J. F. BRENNAN, *Earthq. Notes, East. Sect. Seis. Soc. America*, 7 (1935), 25~26.