Note on the Annual Variation of the Height of Level of Lake Biwa.

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With Pls XX-XXI.

The Lake of Biwa*, in the province of Omi, is the largest of the sort in Japan and is situated near the middle of the Main Island; its surface being about 86 metres above the mean sea level, and its area 46.5 square *ri*‡, or 717.2 sq. km. The observation of the water level along the coast of the lake was made, during the 12 years, 1893-1904, at 22 stations, to which, since 1905, nine more were added; the datum line being 282.53 *shaku* or 85.61 metres above the mean sea level at Tenpo-san, Osaka. The mean height of the surface of the lake water for each month during the 14 years, 1893-1906, obtained by taking the average of the measurements at the different places, is given in Table I.

From Table I it will be observed that the water was highest mostly in December and January; the amount of the fluctuation, or the difference between the maximum and minimum monthly heights, varying between 8.18 *shaku* (=248 cm) and 1.40 *shaku* (=42 cm.). The extreme monthly heights of the water level

* An account of the earthquake zones around the Biwa Lake has been given in the *Bulletin*, Vol. I, No. 3.

† 1 *ri*=36 *chō*=2.4 miles, or 3.927 km.

and their difference in each of the 14 years under consideration are given in Table II.

Table I. Mean Monthly Height of the Level of Lake Biwa*. 1893–1906.

Month. / Year.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	*Mean.*
1893	2.74	2.82	2.68	3.71	3.93	3.90	2.62	1.76	2.00	2.69	2.86	2.41	2.84
1894	2.24	2.15	2.49	3.44	3.47	2.30	1.35	0.77	0.66	0.28	0.20	0.28	1.64
1895	0.61	0.98	2.01	2.39	1.78	1.49	3.12	6.18	3.99	2.84	2.10	1.44	2.41
1896	1.56	1.79	2.34	3.23	3.26	2.42	5.02	5.63	9.74	7.22	4.51	3.73	4.20
1897	3.05	2.92	2.67	3.52	3.98	3.05	2.80	2.05	2.59	3.72	2.24	1.77	2.86
1898	1.90	2.30	2.40	2.28	1.95	2.12	2.69	1.52	1.71	1.50	0.93	1.13	1.87
1899	1.67	2.19	3.45	3.07	2.21	2.02	2.15	1.83	3.18	4.29	2.95	1.79	2.57
1900	1.49	1.62	1.60	2.72	3.16	1.93	1.76	1.62	1.80	2.77	2.23	1.90	2.05
1901	1.74	1.48	1.25	1.71	1.44	0.76	2.56	1.70	0.83	0.24	0.17	0.04	1.16
1902	-0.05	0.06	0.47	1.10	2.23	1.99	1.62	2.33	1.15	1.23	0.41	-0.11	1.04
1903	0.31	1.78	0.83	2.10	2.40	2.34	4.27	2.90	0.52	0.56	0.35	0.43	1.56
1904	0.45	0.24	0.58	0.48	0.91	0.91	2.22	1.24	1.52	1.92	0.94	0.80	1.02
1905	1.33	1.41	1.69	1.37	1.17	1.29	2.93	2.30	1.73	0.37	0.08	-0.02	1.30
1906	1.00	1.55	1.90	1.27	0.61	0.67	2.01	1.17	1.05	1.55	1.25	0.78	1.23
Mean.	1.43	1.66	1.88	2.31	2.32	1.94	2.65	2.36	2.32	2.23	1.52	1.17	1.98

* The heights are expressed in *shaku* (1 *shaku* = $^1/_{3.3}$ metre), the datum line being 282.53 *shaku* above the mean sea level at Tenpo-san, Osaka.

Annual Variation: the Height of Surface of Lake Biwa compared with the Amount of Precipitation and Barometric Pressure.

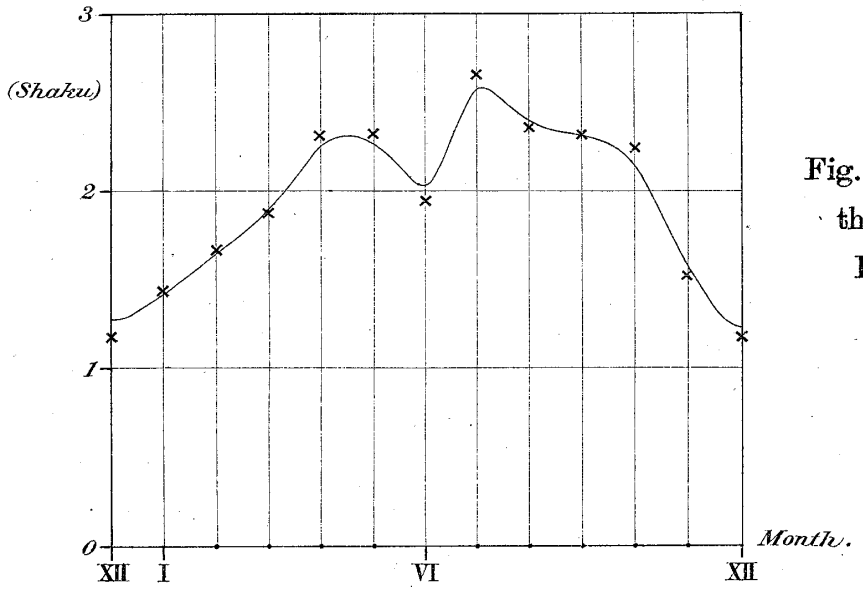

Fig. 1. Height of the Surface of Lake Biwa.

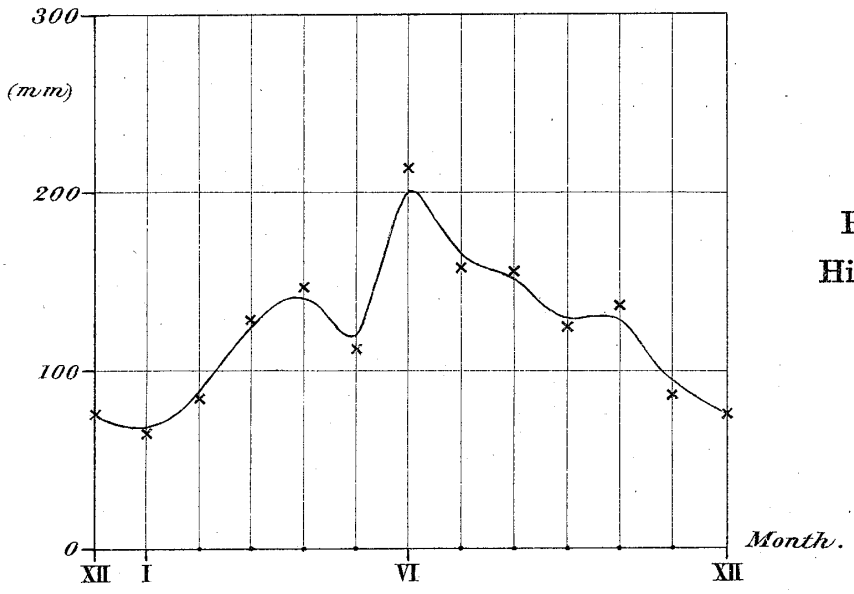

Fig. 2. Precipitation at Hikone and Kyoto

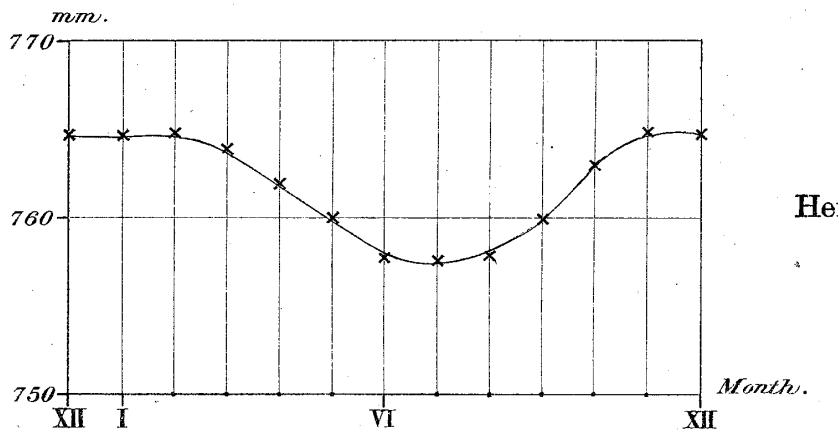

Fig. 3. Barometric Height at Hikone.

Annual Variation of the Seismic Frequency and the Pressure at the Lake Bottom.

Fig. 4. Seismic Frequency at Hikone.

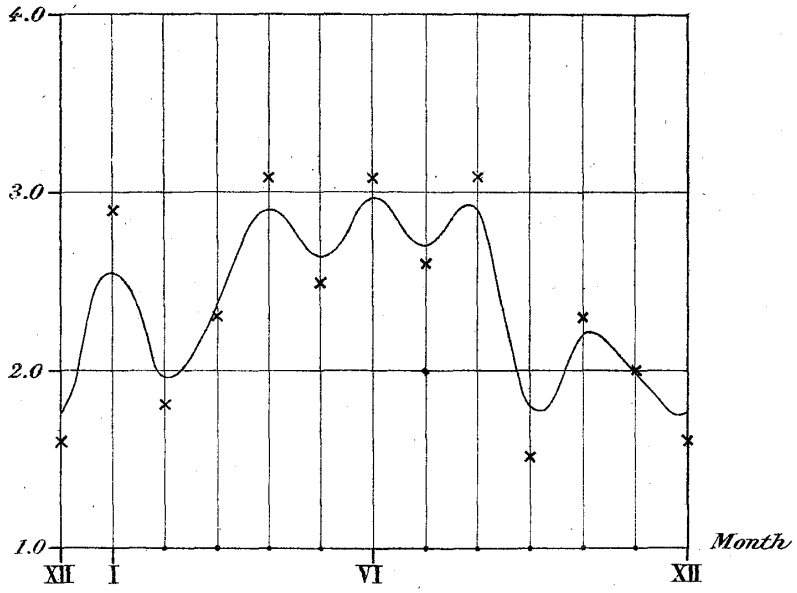

Fig. 5. Total Pressure at the Lake Bottom.

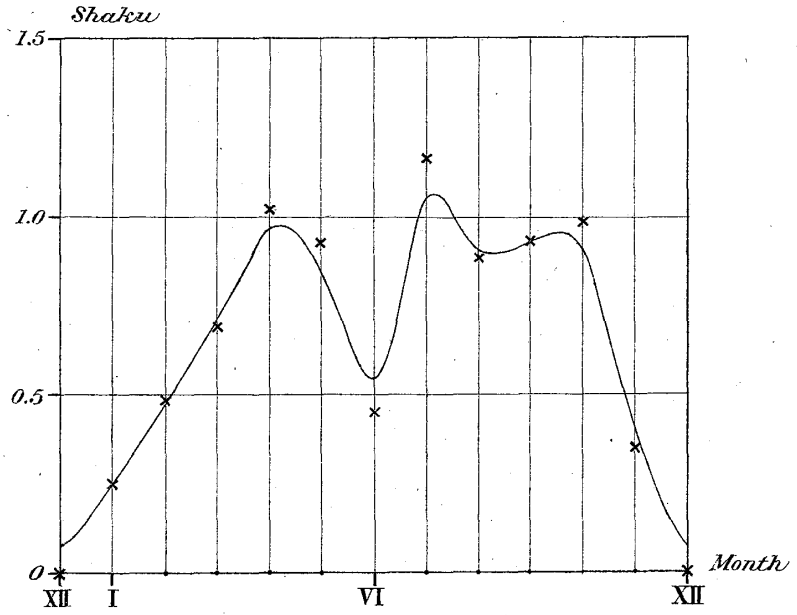

Table II. Maximum and Minimum Heights of the Lake Water.

Year	Maximum Height.		Minimum Height.		Difference.
	shaku		*shaku*		*shaku*
1893	3.93	(May)	1.76	(Aug.)	2.17
1894	3.47	(„)	0.20	(Nov.)	3.27
1895	6.18	(Aug.)	0.61	(Jan.)	5.57
1896	9.74	(Sept.)	1.56	(„)	8.18
1897	3.98	(May)	1.77	(Dec.)	2.21
1898	2.69	(July)	0.96	(Nov.)	1.73
1899	4.29	(Oct.)	1.67	(Jan.)	2.62
1900	3.16	(May)	1.49	(„)	1.67
1901	2.56	(July)	0.04	(Dec.)	2.52
1902	2.33	(Aug.)	−0.11	(„)	2.44
1903	4.27	(July)	0.31	(Jan.)	3.96
1904	2.22	(„)	0.24	(Feb.)	1.98
1905	2.93	(„)	0.02	(Dec.)	2.95
1906	2.01	(„)	0.61	(May)	1.40

In the following table I give the average heights of the lake water for the different months of the year deduced from Table I, and also the mean monthly barometric heights observed at the meteorological observatory of Hikone, which is situated on the south-eastern coast of Lake Biwa.

Table III. Annual Variations of the Height of Lake Water, and of the Barometric Pressure at Hikone.

Month.	Lake Level		Barometric Pressure.			Total pressure at the Lake Bottom.	
	(i) mean Height.	(ii) Relative Height.	(iii) Monthly mean.	(iv) Variation.	(v) Same as (iv), expressed in equivalent column of water.	(vi) Sum of (ii) and (v)	(vii) Relative Variation.
	shaku	*shaku*	mm	mm	*shaku*	*shaku*	*shaku*
I	1.43	**0.26**	764.5	6.9	0.31	0.57	**0.25**
II	1.66	**0.49**	64.7	7.1	0.32	0.81	**0.49**
III	1.88	**0.71**	63.9	6.3	0.28	0.99	**0.67**
IV	2.31	**1.14**	61.9	4.3	0.19	1.33	**1.01**
V	2.32	**1.15**	59.8	2.2	0.10	1.25	**0.93**
VI	1.94	**0.77**	57.6	0.0	0.00	0.77	**0.45**
VII	2.65	**1.48**	57.6	0.0	0.00	1.48	**1.16**
VIII	2.36	**1.19**	57.8	0.2	0.01	1.20	**0.88**
IX	2.32	**1.15**	59.8	2.2	0.10	1.25	**0.93**
X	2.23	**1.06**	63.0	5.4	0.24	1.30	**0.98**
XI	1.52	**0.35**	64.8	7.2	0.32	0.67	**0.35**
XII	1.17	**0.00**	64.7	7.1	0.32	0.32	**0.00**

With regard to the annual variation of the lake level, we see, from (ii), Table III, that the difference between the maximum and minimum monthly heights was 1.48 *shaku* (=44.9 cm.), the corresponding change in the volume of the water of the lake being $10^8 \times 3.22$ cubic metres or about 0.322 cubic km.

As will be seen from the graphical illustration in Fig. 1 (Pl. XX), the level was higher in April to October than during the other months, and its annual variation is nearly opposite to that of the barometric pressure (Fig. 2). The amount of fluctua-

tion of the monthly mean of the latter is, however, only 7.2 mm of mercury (=0.32 *shaku* of water), or about one-fifth of that of the former; the annual variation of the lake level depending probably almost entirely on the precipitation in the surrounding districts.

The following table gives the average monthly amount of precipitation at Hikone and at Kyoto, the latter place being situated some distance to the south-west of the Lake of Biwa.

Table IV. Precipitation at Hikone and Kyoto.

Month.	Hikone	Kyoto	*Mean*
	mm	mm	mm
January	76.8	52.4	64.6
February	107.4	62.7	85.1
March	145.0	114.3	129.7
April	126.1	168.3	147.2
May	77.0	148.3	112.7
June	188.7	240.5	214.6
July	135.5	182.7	159.1
August	189.7	120.9	155.3
September	93.4	157.4	125.4
October	137.4	135.8	136.6
November	82.7	86.6	84.7
December	101.5	50.1	75.8

As illustrated in Fig. 2, the annual variation of the precipitation at Kyoto and Hikone is very similar to that of the height of the lake surface (Fig. 1).

Annual variation of seismic frequency at Hikone. The monthly number of earthquakes observed instrumentally at

the meteorological observatory of Hikone, between 1894 and 1907, are as follows.

Table V. Monthly Earthquake Numbers at Hikone.

Month. / Year.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	*Sum.*
1894	20*	6	3	0	2	7	8	9	1	4	3	6	69
1895	11	1	2	6	2	1	5	1	7	7	2	6	51
1896	4	1	2	10	6	13	9	8	1	1	1	2	58
1897	3	3	4	7	3	1	0	6	1	2	1	0	31
1898	1	0	0	2	0	0	0	4	0	1	2	0	10
1899	3	2	6	2	5	2	1	0	0	0	4	1	26
1900	1	0	2	1	2	3	2	1	3	6	7	3	31
1901	2	2	1	1	1	1	2	0	2	0	4	0	16
1902	2	1	3	0	2	4	2	1	2	1	1	0	19
1903	1	1	3	0	0	0	4	1	0	0	1	1	12
1904	1	0	1	1	2	3	0	1	1	1	1	0	12
1905	1	1	1	0	0	4	0	5	1	4	0	3	20
1906	6	3	1	5	5	1	3	5	1	2	0	0	32
1907	2	4	3	8	5	4	1	1	1	3	1	0	33
Mean.	2.9	1.8	2.3	3.1	2.5	3.1	2.6	3.1	1.5	2.3	2.0	1.6	

As shown in Fig. 4 (Pl. XXI), the annual variation of the seismic frequency at Hikone indicates the maximum in August, differing in this respect from those for the other stations, such as Kyoto, Nagoya, and Kumamoto, which are shaken more by earthquakes of inland origin, and whose seismic frequency is generally minimum in Summer‡. Now, according to Table III,

* Excluded in deducing the mean frequency, being due to the abundance of after-shocks of the severe Mino-Owari earthquake of Jan. 10, 1894.

‡ See the "Publications," No. 8.

the total pressure at the lake bottom, or the sum of the water and atmospheric pressures, is maximum in July, and its annual variation is somewhat similar to that of the height of the water level. The change of pressure at the bottom of the lake, whose mean annual amplitude is 1.16 *shaku* (=35 cm), or 3.6 times greater than that of the barometric pressure, may possibly be the cause of the annual variation of the seismic frequency peculiar to Hikone.