SOME RESEARCHES IN THE FAR EASTERN SEASONAL CORRELATIONS.

(SECOND NOTE)

BY

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§ 1.—Correlation between the July temperatures at San Francisco, Cal. and Erimo in Northern Japan.—It is a well known fact that in the summer season the North Pacific high area is a controlling agent of the air temperature on both sides of the North Pacific. A slight shifting to the westward of this action-centre gives temperatures below the normal on the west coast of the United States, and the eastward shifting of the high area abnormally low temperatures on the east coast of Northern Japan.

An opposition is traced between the July temperatures at San Francisco in California and Erimo in Hokkaido. We give below the July temperatures at both stations :—

TABLE I.—JULY TEMPERATURES AT SAN FRANCISCO
AND ERIMO.

x in the second column means the air temperature at San Francisco and y in the third column that at Erimo.

Year	x	y	Δx	Δy	$\Delta x.\Delta y$	$(\Delta x)^2$	$(\Delta y)^2$
1890.....	15.4	15.9	+1.1	+0.9	+0.99	1.21	0.81
1891.....	15.2	15.8	+0.9	+0.8	+0.72	0.81	0.64
1892.....	14.5	17.8	+0.2	+2.8	+0.56	0.04	7.84
1893.....	13.7	13.8	-0.6	-1.2	+0.72	0.36	1.44
1894.....	13.6	16.5	-0.7	+1.5	-1.05	0.49	2.25
1895.....	14.7	15.3	+0.4	+0.3	+0.12	0.16	0.09
1896.....	15.2	14.9	+0.9	-0.1	-0.09	0.81	0.01
1897.....	14.6	14.0	+0.3	-1.0	-0.30	0.09	1.00

Year	x	y	Δx	Δy	$\Delta x \Delta y$	$(\Delta x)^2$	$(\Delta y)^2$
1898.....	13.4	15.1	-0.9	+0.1	-0.09	0.81	0.01
1899.....	13.3	16.9	-1.0	+1.9	-1.90	1.00	3.61
1900.....	14.6	13.6	+0.3	-1.4	-0.42	0.09	1.96
1901.....	13.1	16.0	-1.2	+1.0	-1.20	1.44	1.00
1902.....	15.1	14.0	+0.8	-1.0	-0.80	0.64	1.00
1903.....	14.0	14.2	-0.3	-0.8	+0.24	0.09	0.64
1904.....	13.9	15.9	-0.4	+0.9	-0.36	0.16	0.81
1905.....	15.3	14.5	+1.0	-0.5	-0.50	1.00	0.25
1906.....	14.2	15.6	-0.1	+1.6	-0.16	0.01	2.56
1907.....	14.4	14.0	+0.1	-1.0	-0.10	0.01	1.00
1908.....	14.1	13.5	-0.2	-1.5	+0.30	0.04	2.25
1909.....	14.3	14.5	0.0	-0.5	0.00	0.00	0.25
1910.....	13.6	15.0	-0.7	0.0	0.00	0.49	0.00
1911.....	13.6	16.5	-0.7	+1.5	-1.05	0.49	2.25
1912.....	14.4	14.1	+0.1	-0.9	-0.09	0.01	0.81
1913.....	15.9	13.1	+1.6	-1.9	-3.04	2.56	3.61
1914.....	13.9	14.6	-0.4	-0.4	+0.16	0.16	0.16
Mean	14.3	15.0	—	—	—	—	—
Sum	—	—	—	—	-7.34	12.97	35.25

The temperature data for Erimo have been taken from Annual reports of the Central Meteorological Observatory, Tôkyô. The daily mean temperature has been calculated from the six-daily observations, and approximates very closely the true mean temperature. The San Francisco data have been extracted from Professor A.G. McAdie's Climatology of California and Reports of Chief of the Weather Bureau. The mean temperatures at San Francisco given in the above table are the sum of the mean maximum and mean minimum temperatures divided by 2, and are not reduced to the true mean temperatures as Hofrat Professor J. von Hann* already remarked. Von Hann has given a small table of corrections

* J. von Hann: Klimatologie von Kalifornien. M. Z. 1907. p. 455.

A. G. McAdie: Die wahre Mitteltemperatur von San Francisco, Kalifornien M. Z. 1908. p. 330.

to be applied to the long years' means to reduce them to the true monthly means. But it must be remarked that generally the corrections are different from year to year. Hence, the San Francisco temperatures given in the above table differ from the true monthly means, and the difference from the true mean temperature is different year for year. This is specially the case when a secular variation with the amplitude of the order of magnitude comparable to that of the variation under consideration is superposed with the latter. In such a case the usual method for calculating the correlation-coefficient gives an unduly small value.

From Fig. 1. which shows the above data in graphic form we see that there is a well established correlation between the July temperatures at San Francisco and Erimo, and the abnormally high temperature on the Californian coast is associated with abnormally low temperature on this shore of the Pacific.

Fig. 1.

But the correlation-coefficient deduced from the data given in Table I. is -0.34 and the probable error ± 0.119 . These values

are simply suggestive of a connection between the July temperatures on both sides of the Pacific, but they are far from being conclusive of the connection. This apparent discrepancy between the conclusions arrived at by the graphic representation and the calculation arises from the fact that the fundamental assumption for the calculation of correlation-coefficient is not fulfilled in the present case, that is to say, some unknown variations are superposed to the variation under consideration. Hence it will be rather advisable to compare the variation of temperatures year for year instead of the temperatures themselves. We give in Table 2. the variations of the July temperatures at San Francisco and Erimo. In this table Δx means the variations of the San Francisco temperatures and Δy those of the Erimo temperatures.

TABLE 2.—VARIATIONS OF THE JULY TEMPERATURES.

Year	x	y	Δx	Δy	$\Delta x, \Delta y$	$(\Delta x)^2$	$(\Delta y)^2$
1889	14.9	14.8					
1890	15.4	15.9	+ 0.5	+ 1.1	+ 0.55	0.25	1.21
1891	15.2	15.8	- 0.2	- 0.1	+ 0.02	0.04	0.01
1892	14.5	17.8	- 0.7	+ 2.0	- 1.40	0.49	4.00
1893	13.7	13.8	- 0.8	- 4.0	+ 3.20	0.64	16.00
1894	13.6	16.5	- 0.1	+ 2.7	- 0.27	0.01	7.29
1895	14.7	15.3	+ 1.1	- 1.2	- 1.32	1.21	1.44
1896	15.2	14.9	+ 0.5	- 0.4	- 0.20	0.25	0.16
1897	14.6	14.0	- 0.6	- 0.9	+ 0.54	0.36	0.81
1898	13.4	15.1	- 1.2	+ 1.1	- 1.32	1.44	1.21
1899	13.3	16.9	- 0.1	+ 1.8	- 0.18	0.01	3.24
1900 ..	14.6	13.6	+ 1.3	- 3.3	- 4.29	1.69	10.89
1901	13.1	16.0	- 1.5	+ 2.4	- 3.60	2.25	5.76
1902	15.1	14.0	+ 2.0	- 2.0	- 4.00	4.00	4.00
1903	14.0	14.2	- 1.1	+ 0.2	- 0.22	1.21	0.04
1904	13.9	15.9	- 0.1	+ 1.7	- 0.17	0.01	2.89

Year	x	y	Δx	Δy	$\Delta x \Delta y$	$(\Delta x)^2$	$(\Delta y)^2$
1905.....	15.3	14.5	+1.4	-1.4	-1.96	1.96	1.96
1906.....	14.2	15.6	-1.1	+1.1	-1.21	1.21	1.21
1907.....	14.4	14.0	+0.2	-1.6	-0.32	0.04	2.56
1908.....	14.1	13.5	-0.3	-0.5	+0.15	0.09	0.25
1909.....	14.3	14.5	+0.2	+1.0	+0.20	0.04	1.00
1910.....	13.6	15.0	-0.7	+0.5	-0.35	0.49	0.25
1911.....	13.6	16.5	0.0	+1.5	0.00	0.00	2.25
1912.....	14.4	14.1	+0.8	-2.4	-1.92	0.64	5.76
1913.....	15.9	13.1	+1.5	-1.0	-1.50	2.25	1.00
1914.....	13.9	14.6	-2.0	+1.5	-3.00	4.00	2.25
Sum.....	—	—	-1.0	-0.2	-22.57	25.11	77.44

A glance at this table shows that in 25 cases we find 19 cases in which the signs are the reverse of each other and 6 cases in which they agree. Hence the probability of the opposition of the air temperatures at San Francisco and Erimo is 19/25 or 76%. The correlation-coefficient deduced from the above data is -0.51 and the probable error ± 0.102 . It may be therefore concluded that in July a temperature see-saw is fairly established on both sides of the North Pacific. *When the July temperature at Erimo in Northern Japan is higher than the average the temperature at San Francisco in California is abnormally low, and vice versa.*

§ 2. Correlation between the April temperature at Irkutsk and the July temperature at San Francisco.—In the first note* of my researches on this subject I have traced a remarkable parallelism between the March barometric gradient at Zikawai near Shanghai and the July temperature on the east coast of Northern Japan. This and the result given in the preceding paragraph induce me to search for an eventual correlation between

* Meteorological Society of Japan. No. 12 Dec. 1915.

the spring temperature on the Asiatic continent and the summer, temperature on the American coast of the North Pacific. After trials I have traced a marked opposition between the April temperature at Irkutsk in Eastern Siberia and the air temperature at San Francisco for the following July. The temperature data for both stations are given in Table 3. The temperatures at Irkutsk have been taken from *Annuel de l'Observatoire physique central Nicolas* the record beginning from 1887. The recent records are unluckily not within my reach. In the table x means the April temperature at Irkutsk and y the July temperature at San Francisco.

TABLE 3.—TEMPERATURE-CORRELATION AT IRKUTSK
AND SAN FRANCISCO.

Year	x	y	Δx	Δy	$\Delta x \Delta y$	$(\Delta x)^2$	$(\Delta y)^2$
1887	1.7	13.7	+0.9	-0.7	-0.63	0.81	0.49
1888	-1.6	16.3	-2.4	+1.9	-4.56	5.76	3.61
1889	0.2	14.9	-0.6	+0.5	-0.30	0.36	0.25
1890	-0.3	15.4	-1.1	+1.0	-1.10	1.21	1.00
1891	-0.3	15.2	-1.1	+0.8	-0.88	1.21	0.64
1892	0.3	14.5	-0.5	+0.1	-0.05	0.25	0.01
1893	4.6	13.7	+3.8	-0.7	-2.66	14.44	0.49
1894	-0.8	13.6	-1.6	-0.8	+1.28	2.56	0.64
1895	2.0	14.7	+1.2	+0.3	+0.36	1.44	0.09
1896	1.4	15.2	+0.6	+0.8	+0.48	0.36	0.94
1897	1.0	14.6	+0.2	+0.2	+0.04	0.04	0.04
1898	1.9	13.4	+1.1	-1.0	-1.10	1.21	1.00
1899	3.9	13.3	+3.1	-1.1	-3.41	9.61	1.21
1900	-1.7	14.6	-2.5	+0.2	-0.50	6.25	0.04
1901	1.0	13.1	+0.2	-1.3	-0.26	0.04	1.69
1902	-0.8	15.1	-1.6	+0.7	-1.12	2.56	0.49
1903	0.6	14.0	-0.2	-0.4	+0.08	0.04	0.16
1904	-0.3	13.9	-1.1	-0.5	+0.55	1.21	0.25

Year	x	y	Δx	Δy	$\Delta x \Delta y$	$(\Delta x)^2$	$(\Delta y)^2$
1905	-1.5	15.3	-2.3	+0.9	-2.07	5.29	0.81
1906	4.5	14.2	+3.7	-0.2	-0.74	13.69	0.04
1907	1.9	14.4	+1.1	0.0	0.00	1.21	0.00
Mean	0.8	14.4	—	—	—	—	—
Sum	17.7	93.1	—	—	16.59	68.34	13.59

$$r = -\frac{16.59}{\sqrt{68.34} \sqrt{13.59}} = -0.53 \quad w = \pm 0.6745 \frac{(1-r^2)}{\sqrt{21}} = \pm 0.106$$

Looking at the columns showing the departures from the normal it will be seen that the signs are the reverse in 15 cases and the same in 6 cases out of the twenty one cases under consideration. The correlation-coefficient deduced from the above data is -0.53 and the probable error ± 0.106 .

Fig. 11.

Hence we may conclude that *when the April temperature at Irkutsk is higher than the normal we may expect with a high degree of probability that the temperature at San Francisco in the following July will be abnormally low, and vice versa.*

The above result will be of some interest on account of its bearing upon the possibility of issuing a seasonal forecast on the

Pacific coast of the United States, which Professor A.G. McAdie* has ardently advocated.

§ 3.—Correlation between the winter barometric pressure at Zikawei near Shanghai and the summer barometric pressure at Nemuro in Northern Japan.—A marked opposition is traced between the barometric heights at Zikawei in January and February and those at Nemuro in July and August. We give below the barometric data for both stations. In this table x refers to Zikawei and y to Nemuro.

TABLE 4.—MEAN BAROMETRIC PRESSURES AT ZIKAWEI
IN JANUARY AND FEBRUARY AND AT NEMURO
IN JULY AND AUGUST.

Year	x	y	Δx	Δy	$\Delta x \Delta y$	$(\Delta x)^2$	$(\Delta y)^2$	Δx	Δy
1886	770.3	758.4	+1.2	+0.2	+0.24	1.44	0.04		
1887	769.0	758.4	-0.1	+0.2	-0.02	0.01	0.04	-0.7	± 0.0
1888	769.4	756.6	+0.3	-1.6	-0.46	0.09	2.56	+0.4	-1.8
1889	770.4	757.4	+1.3	-0.8	-1.04	1.69	0.64	+1.0	+0.8
1890	768.1	759.2	-1.0	+1.0	-1.00	1.00	1.00	-2.3	+1.8
1891	769.3	757.4	+0.2	-0.8	-0.16	0.04	0.64	+1.2	-1.8
1892	768.6	757.9	-0.5	-0.3	+0.15	0.25	0.09	-0.7	+0.5
1893	769.7	757.8	+0.6	-0.4	-0.24	0.36	0.16	+1.1	-0.1
1894	769.1	756.6	± 0.0	-1.6	0.00	0.00	2.56	-0.6	-1.2
1895	768.1	758.8	-1.0	+0.6	-0.60	1.00	0.36	-1.0	+2.2
1896	769.4	758.3	+0.3	+0.1	+0.03	0.09	0.01	+1.3	-0.5
1897	769.3	758.2	+0.2	± 0.0	0.00	0.04	0.00	-0.1	-0.1
1898	767.3	757.8	-1.8	-0.4	+0.72	3.24	0.16	-2.0	-0.4
1899	769.0	757.8	-0.1	-0.4	+0.04	0.01	0.16	+1.7	± 0.0
1900	770.4	757.0	+1.3	-1.2	-1.56	1.69	1.44	+1.4	-0.8
1901	769.9	758.2	+0.8	± 0.0	0.00	0.64	0.00	-0.5	+1.2

* A.G. McAdie : Forecasting on the Pacific coast. M. W. R. 1908. p. 98.

Year	x	y	Δx	Δy	$\Delta x \Delta y$	$(\Delta x)^2$	$(\Delta y)^2$	Δx	Δy
1902	769.7	759.0	+0.6	+0.8	+0.48	0.36	0.64	-0.2	+0.8
1903	770.6	757.7	+1.5	-0.5	-0.75	2.25	0.25	+0.9	-1.3
1904	769.3	758.5	+0.2	+0.3	+0.06	0.04	0.09	-1.3	+0.8
1905	767.3	758.9	-1.3	+0.7	-1.26	3.24	0.49	-2.0	+0.4
1906	767.9	758.3	-1.2	+0.1	-0.12	1.44	0.01	+0.6	-0.6
1907	769.3	758.7	+0.2	+0.5	+0.10	0.04	0.25	+1.4	+0.4
1908	769.8	758.8	+0.7	+0.6	+0.42	0.49	0.36	+0.5	+0.1
1909	768.5	759.1	-0.6	+0.9	-0.54	0.36	0.81	-0.4	+0.3
1910	768.3	759.8	-0.8	+1.6	-1.28	0.64	2.56	-0.2	+0.7
Sum	—	—	—	—	-7.19	20.45	15.32		
Mean.	769.1	758.2	—	—	—	—	—		

$$r = -\frac{7.19}{\sqrt{20.45} \sqrt{15.32}} = -0.41 \quad w = \pm 0.6745 \frac{(1-r^2)}{\sqrt{n}} = \pm 0.112$$

The last two columns contain the variations of the barometric heights from year to year at both stations. The correlation-coefficient deduced from these quantities is -0.41 . From the above results we may conclude that when the barometer stands higher than the average at Irkutsk in January and February we may expect that the pressure at Nemuro in the following July and August will be abnormally low.