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THE NILE FLOOD AND WORLD WEATHER

BY

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PRICE TO NON-FELLOWS, TWO SHILLINGS AND SIXPENCE

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In a study of this kind our object is to establish relationships with the help of long-series data, and we have first to find a series for the Nile flood. Aswan discharges provide the truest measure of the flood, monthly values of which have been kindly communicated by the Director-General of the Physical Department, Cairo; and we have to add together the four months July to October to cover the period of the flood. This is done in Table I. where the departures from the mean are given, while approximate figures are added for which the standard deviation is $\sqrt{20}$: as was shown in a recent paper,[1] the latter are convenient for computing correlation coefficients.

The centres of world weather which were examined in relation to the Nile include those adopted by Sir Gilbert Walker in his "*Further study of world weather*,"[2] and his plan of working with quarterly values is followed. Coefficients were calculated also with temperatures, rainfall, ice and wind, covering in each case a range of from two quarters before to the same after the Nile flood. The results are given in Tables II.–IV.

Looking at Table II. of coefficients with pressure we notice a high negative figure with Cairo, $-\cdot 64$ for the June–August quarter. The connection is closest in June–August, but it begins in March–May and persists throughout the subsequent quarters. Although rainfall is usually associated with low pressure, this can hardly be the whole explanation in the present case, as Cairo is far from Abyssinia, and Zanzibar, which is fairly near the rainfall area, has a much smaller coefficient. Again, the coefficient of $-\cdot 50$ with Port Darwin pressure June–August, of $\cdot 36$ with that of S. America, of $\cdot 54$ with that of Honolulu, and of $\cdot 36$ with Tokio pressure, indicate that, like the Indian monsoon, the Nile behaves as a member of the first group of the southern oscillation.

The Abyssinian rainfall was at one time regarded as provided by the moist winds from the Indian ocean, but in 1910 Mr. J. I. Craig urged many reasons for believing that the S. Atlantic ocean was the source of the rain-bearing winds, and he found a coefficient of $+\cdot 605$ with St. Helena pressure June–August. At that time only 16 years of St. Helena pressures were available; now, with 29 years, the coefficient is only $+\cdot 06$. Nor does the St. Helena wind velocity bear any relation to the Nile.

With S. America pressure in the quarter March–May before the Nile flood we find a coefficient of $+\cdot 38$, and with snowfall on the Himalayas in May a coefficient of $-\cdot 36$, results which are in agreement with those obtained by Sir G. Walker in 1910. On the other hand, Zanzibar rainfall in May, which affects Indian rainfall adversely, shows only a small coefficient of $-\cdot 18$.

After a high Nile flood the N. Atlantic circulation is weak, as will be seen from the coefficients with December–February Iceland pressure

[1] *London, Q.J.R. Meteor. Soc.*, **52**, 1926, p. 73.
[2] *Calcutta, Ind. Met. Mem.*, **24**, 1924, pt. 9.

+·38 and of the Azores of −·40, and from the following results also for the December–February quarter:

Greenwich temperature	−·54	Valencia temperature	−·32
Berlin temperature	−·48	Stornoway temperature	−·46
Vardo temperature	−·22	Kristiansund temperature	−·40

British Isles rainfall . . . . . −·40

Other associations with a good Nile are low equatorial temperatures, *e.g.* Samoa −·72 Batavia −·52, Senegal −·48 and Port au Prince −·40, all in December–February following; and pressures in the same season

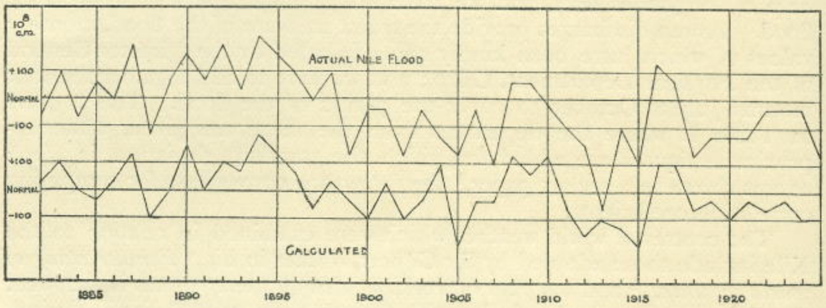

FIG. 1.—Result for prediction on June 1 of Nile flood.

are also low, especially in the South Indian Ocean, as the following coefficients show:

Tokio	−·48	South Australia	−·42
Cairo	−·42	Cape	−·46
Port Darwin	−·48	Zanzibar	−·50

However, S. Rhodesia rain is in excess, its coefficient being +·44.

Like the monsoon, the Nile has closer relations with subsequent than with preceding weather. A rough test of this statement may be made by counting the coefficients ≧ ·40 in the tables.

	Coefficients ≧ ·40.		
	Before Nile.	Same Quarter.	After Nile.
Pressure	4	3	10
Temperature	8	9	9
Rain, etc.	0	3	2

While there are 12 coefficients ≧ ·40 with weather in the two preceding quarters, there are 15 with the contemporary quarter and 21 with the two subsequent seasons.

There is some evidence of a simultaneous connection with antarctic conditions. With temperature June–August we find Cape Pembroke +·54, Punta Arenas +·56, and S. Orkneys +·42; so that an excess of temperature here goes with a high Nile.

Formula of prediction.

We have the following coefficients :

	1.	2.	3.	4.
1. Nile	100	−·56	−·56	−·54
2. Dutch Harbour temperature March–May	−·56	100	·36	·24
3. Samoa temperature December–May . .	−·56	·36	100	·60
4. Port Darwin pressure March–May . .	−·54	·24	·60	100

Solving the equations

$$\begin{aligned} -56 &= 100a + 36b + 24c, \\ -56 &= 36a + 100b + 60c, \\ -54 &= 24a + 60b + 100c, \end{aligned}$$

we find

$$a = -\cdot 40, \quad b = -\cdot 23, \quad c = -\cdot 30,$$

and the regression equation becomes

$$\{\text{Nile}\} = -\cdot 40\ \{\text{Dutch Harb. temperature}\} - \cdot 23\ \{\text{Samoa temperature}\} - \cdot 30\ \{\text{P. Darwin pressure}\},$$

where { } indicates that departures are divided by the respective standard deviations.

Also,
$$\begin{aligned} R^2 &= (\cdot 40 \times \cdot 56) + (\cdot 23 \times \cdot 56) + (\cdot 30 \times \cdot 54) \\ &= \cdot 515 \end{aligned}$$
and
$$R = \cdot 72.$$

Thus the joint coefficient is ·72. The successive values are plotted in Fig. 1.

I have to acknowledge my indebtedness to Sir Gilbert Walker, F.R.S., for valuable advice, and to the Meteorological Office for assistance with the long-series data.

SUMMARY.

Correlation coefficients are given with pressure, temperature, rain, ice and wind, and it is shown (*a*) that the Nile takes part in the southern oscillation as a member of the first group, (*b*) that equatorial temperatures are in inverse relation to the Nile, and (*c*) that the winter North Atlantic circulation varies inversely with the preceding Nile. St. Helena pressure has no contemporary relationship with the Nile. A formula is derived for prediction on June 1 with a joint coefficient of ·72.

[TABLE

TABLE I.—Nile Flood Departures from the Mean.

Departures (D) in 10^8 c. metres. D′ (for correlation) = ·0302 D.
Standard Deviation of D = 148·1.
Mean flood 1869–1925 = 678 × 10^8 c.m.

Year.	D.	D′.	Year.	D.	D′.	Year.	D.	D′.
1869	184	6	1888	−148	−4	1907	−239	−7
1870	219	7	1889	55	2	1908	50	2
1871	95	3	1890	162	5	1909	56	2
1872	149	5	1891	71	2	1910	−31	−1
1873	−46	−1	1892	210	6	1911	−111	−3
1874	269	8	1893	45	1	1912	−176	−5
1875	138	4	1894	242	7	1913	−393	−12
1876	137	4	1895	180	5	1914	−91	−3
1877	−153	−5	1896	111	3	1915	−242	−7
1878	236	7	1897	−16	0	1916	129	4
1879	182	5	1898	111	3	1917	68	2
1880	58	2	1899	−210	−6	1918	−190	−6
1881	12	0	1900	−23	−1	1919	−122	−4
1882	−58	−2	1901	−39	−1	1920	−116	−4
1883	94	3	1902	−208	−6	1921	−145	−4
1884	−62	−2	1903	−22	−1	1922	−32	−1
1885	60	2	1904	−129	−4	1923	−25	−1
1886	−7	0	1905	−195	−6	1924	−49	−1
1887	211	6	1906	−39	−1	1925	−192	−6

TABLE II.—NILE FLOOD AND PRESSURES: COEFFICIENTS × 100.

STATION.	Years of data.	2 qrs. before Nile. Dec.-Feb.	1 qr. before Nile. Mar.-May.	Same qr. June-Aug.	1 qr. after Nile. Sept.-Nov.	2 qrs. after Nile. Dec.-Feb.
Iceland	46	6	18	−28	20	38
Alaska	19	6	−6	6	32	24
Cent. Siberia[1]	40	22	4	−14	−4	10
Vienna	46	8	−16	−6	−18	−8
Azores	46	4	−20	2	−18	−40
Charleston	46	16	−18	2	0	24
San Francisco	48	−18	36	−24	−6	6
Tokio	39	−12	4	36	−16	−48
Cairo	54	−28	−44	−64	−40	−42
Honolulu	38	2	16	54	−2	−38
N.W. India[2]	46	−38	−20	−8	−38	−34
Port Darwin	44	−46	−54	−50	−50	−48
Mauritius	46	−14	14	−10	22	−4
Samoa	31	18	30	20	0	28
S.E. Australia[3]	45	−30	−20	−26	−32	−42
Cape	46	−18	12	0	−6	−46
S. America[4]	46	−16	38	36	0	−2
Zanzibar	31	−44	−20	−30	−38	−50
St. Helena	29	2	−18	6	−40	−32
S. Orkneys	21	8	−4	−6	−2	−34

[1] Irkutsk + Eneseisk. [2] Lahore + Karachi. [3] Brisbane + Adelaide + Alice Springs. [4] Santiago + Cordoba + Buenos Aires.

TABLE III.—NILE FLOOD AND TEMPERATURES: COEFFICIENTS × 100.

STATION.	Years of data.	2 qrs. before Nile. Dec.-Feb.	1 qr. before Nile. Mar.-May.	Same qr. June-Aug.	1 qr. after Nile. Sept.-Nov.	2 qrs. after Nile. Dec.-Feb.
Dutch Harbour	41	−38	−56	−16	−22	−8
Port Simpson and Sitka	24	−38	−44	−38	−38	−46
San Francisco	30	−24	−6	−16	−12	−36
Tokio	45	12	6	34	8	8
Honolulu	30	4	−6	−32	−18	−16
Port Darwin	30	20	4	2	0	−12
Mauritius	27	40	−6	44	−24	6
Samoa	36	−58	−56	−52	−68	−72
Batavia	30	−12	−34	−56	−42	−52
Greenwich	57	−32	−12	12	−6	−54
Cape Town	35	−14	−40	−20	26	14
St. Helena	25	0	−44	−32	−18	0
Madras	30	−12	−22	−46	−36	−16
Hebron (Labrador)	26	−6	34	58	−10	2
S. Orkneys	21	12	2	42	−2	12
Wellington	30	36	34	12	18	22
P. Arenas	29	−8	2	56	22	14
Cape Pembroke	14	−4	18	54	−30	−8
Surgut	25	−28	28	34	−8	−10
Jakutsk	27	−20	24	40	24	−22
Manila	30	38	8	20	10	12
St. Louis (Senegal)	20	−34	−30	−26	−20	−48
Zanzibar	30	4	2	−8	−34	−36
Santiago	28	−30	−30	−20	−40	−26
Calcutta	30	10	40	−38	−20	−8
Port au Prince	29	−26	8	4	−2	−40
Cordoba	30	−8	−28	−6	−6	−24

TABLE IV.—NILE FLOOD AND RAINFALL, ETC. : COEFFICIENTS × 100.

	Season.	Years of data.	2 qrs. before Nile. Dec.-Feb.	1 qr. before Nile. Mar.-May.	Same qr. June-Aug.	1 qr. after Nile. Sept.-Nov.	2 qrs. after Nile. Dec.-Feb.
RAINFALL—							
British Isles	...	44	−14	−30	16	22	−40
Peninsula, India	June-Sept.	50	...	...	50	...	...
N.W. India	June-Sept.	50	...	...	54	...	...
Java	Oct.-Feb.	41	−18	...	...	...	20
Zanzibar	April	29	...	−12	...	...	...
Zanzibar	May	30	...	−18	...	...	...
S. Rhodesia	Oct.-Apr.	22	−26	...	...	...	44
Sierra Leone	May-Oct.	46	...	...	28	...	...
Cape Town	June-Aug.	37	...	...	−18	...	...
Aden	Mar.-May	40	...	26	...	...	...
Samoa	Dec.-Feb.	31	10	...	...	...	22
Havana	May-Oct.	44	...	...	40	...	...
RIVERS—							
Nile previous year	...	56	...	...	32	...	...
Nile two years before	...	55	...	...	40	...	...
Parana	Mar.-May	33	...	−10	...	...	...
ICE—							
Greenland	Apr.-July	31	...	22	...	...	...
Newfoundland	Mar.-Aug.	43	...	8	...	...	...
Barents	Apr.-Aug.	26	...	−18	−6	...	...
Snowfall, Himalayas	May	39	...	−36	...	...	...
WIND VELOCITY—							
Seychelles	June-Sept.	27	...	...	6	...	...
Seychelles	May	27	...	−24	...	...	...
St. Helena	...	29	−18	10	2	14	−10