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BY

E. W. BLISS, M.A., B.Sc., A.Inst.P.

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In a previous paper[1] it was found that the winter of Western Europe was related to the height of the Nile flood, and presumably, therefore, it is related to other elements of world weather.[2] In order, now, to explore this field more fully, a number of relationships have been evaluated with the December to February temperature of Greenwich as representative of the winter conditions.

The departures from normal for the winters 1868/9 to 1925/6 of Greenwich temperature for December to February are represented by the following series:—

Years.	0	1	2	3	4	5	6	7	8	9
186...										8
187...	−4	−6	3	0	1	−4	−1	7	3	−10
188...	−7	−4	2	3	4	1	−7	−5	−5	−3
189...	−1	−11	−2	−4	1	−9	1	0	4	7
190...	−2	1	−1	5	−1	1	1	−3	1	−2
191...	2	3	6	5	3	2	6	−7	0	0
192...	6	5	4	5	−1	5	3			

The mean from which the departures are reckoned for the sum of the three months of the 24-hour mean temperature is $119^\circ{\cdot}5$ F. The figures have been adjusted by the application of a reduction factor of ·624, to give a standard deviation of $\sqrt{20}$ in order to bring them into the convenient form for the computation of correlation coefficients suggested in an earlier paper.[3]

It may be noticed that since 1909 we have had only two winters colder than the average, namely 1917 and 1924.[4]

The coefficients with pressure are given in Table I. and indicate the well-known association of warm winters with an abnormally large gradient between the Azores and Iceland. The closest of all these relationships is that with Stykkisholm in the same quarter, for which the coefficient is $-{\cdot}60$; but with pressure over the Azores and Vienna the connection is not very marked, the coefficients being only $+{\cdot}26$ and $+{\cdot}16$.

With Cairo pressure, which also plays a part in the North Atlantic

[1] E. W. Bliss, "The Nile Flood and World Weather," *Mem. R. Meteor. Soc.*, Vol. I. No. 5.

[2] W. Georgii found a connection with the rainfall of India. "Beziehungen zwischen den Monsunregen Nordindiens und der Winterwitterung von Europa," *Berlin, Ann. Hydrogr.*, **51**, 1923, p. 16.

[3] Cf. Sir G. T. Walker and E. W. Bliss, "On Correlation Coefficients," *Q.J.R. Meteor. Soc.*, **52**, 1926, p. 73.

[4] In all cases the year indicating a winter is that to which January and February belong.

oscillation,[5] there are the large coefficients of $+\cdot 50$ in the same quarter, December to February, and $+\cdot 48$ in the earlier quarter of June to August, based on 56 years of data. In the case of Ivigtut and Archangel there is a reversal of sign in the previous summer quarter; at Archangel, for instance, we have $-\cdot 38$ for the winter pressure and $+\cdot 36$ for the pressure of the preceding summer.

With pressures which are members of the southern oscillation the relationships do not exceed ·38, except that South Orkneys pressure within the Southern Hemisphere in only 21 years of observations has a relationship of $+\cdot 50$ in the contemporary quarter, December to February.

Passing now to Table II. it can be seen that the Greenwich winter temperature is practically independent of the preceding temperatures there, but that there is a coefficient of $+\cdot 38$ with the subsequent spring temperature.

The temperatures of a number of places in the tropics give positive coefficients throughout the year, and, in the June to August quarter preceding, the coefficient with Madras temperature is $+\cdot 44$, with Batavia temperature $+\cdot 42$, and with Samoa temperature $+\cdot 50$.

At Cape Town the temperature of March to May, nine months in advance, and that of June to August, six months in advance, seem to exert some control, as the coefficients are both $+\cdot 32$ based on a long period of 58 years; but curiously at Durban an opposite effect occurs, the coefficients there being negative.

Another opposition similar to the above is that in autumn between Dutch Harbour temperature, which has a coefficient of $+\cdot 36$, and the temperature of Nikolajewsk in Eastern Siberia, with a coefficient of $-\cdot 48$. In the previous southern winter, Perth temperature gives $+\cdot 44$ and Adelaide $+\cdot 30$.

The temperatures of September to November at Nashville (Tennessee), Mexico, and of the Eastern United States show a probable connection with the English winter three months afterwards.

Among the relationships in Table III. the closest is that of ·62 with the winter rainfall of the British Isles. With the Nile flood the coefficient is the highest of all those relating to previous conditions, being $-\cdot 54$ as computed over 57 years. The coefficients with the rainfall of North-West India and Sierra Leone in June to August before as well as with subsequent Newfoundland ice are not, however, in excess of the largest likely to be produced by mere chance.

If we count the number of coefficients in the tables having the numerical value of ·4 or more we arrive at the following results :—

	Number of Coefficients $\geqq \cdot 4$.		
	Preceding Quarters.	Contemporary Quarter.	Succeeding Quarters.
Pressure . .	1	4	0
Temperature .	8	6	3
Rainfall, etc. .	1	1	1

There are ten of these coefficients with the two preceding quarters, eleven with the one contemporary quarter, and only four with the two sub-

[5] For an account of the northern and southern oscillations, see Sir G. T. Walker, "A Further Study of World Weather," *Calcutta, Ind. Met. Mem.*, 1924, **24**, Pt. 9.

sequent quarters. The big coefficients are, therefore, mainly with previous or contemporary weather, and we may call Greenwich temperature, December to February, a *passive* centre, using a term applied by Sir Gilbert Walker.[6]

In preparing the long-series data I have received very useful help from the Meteorological Office; I wish to express my thanks for this and also for the assistance which Sir Gilbert Walker, F.R.S., has kindly given me.

SUMMARY.

Out of 310 correlation coefficients with Greenwich temperature of December to February as representing winter in North-West Europe the largest appear to indicate the following relationships—

(1) With pressure of the previous summer at Cairo.

(2) With temperatures of the previous June to August at Madras, Samoa, Batavia, and Perth.

(3) With the previous Nile flood, the relationship here being inverse.

The results indicate that conditions in the Southern Hemisphere play a part comparable with that of the North Atlantic oscillation in controlling subsequent winter weather in the British Isles.

[6] Passive centres, in this sense, are those controlled by previous conditions in other regions, while active centres are those which influence subsequent conditions.

[TABLE

TABLE I.—CORRELATION COEFFICIENTS* BETWEEN WINTER TEMPERATURE AT GREENWICH (DECEMBER TO FEBRUARY) AND PRESSURES AT VARIOUS PLACES FOR THE TWO PRECEDING, THE CONTEMPORARY, AND THE TWO SUCCEEDING QUARTERS.

PLACE.	Years of Data.	June-Aug. 2 Quarters earlier.	Sept.-Nov. 1 Quarter earlier.	Dec.-Feb. Contemporary Quarter.	Mar.-May. 1 Quarter later.	June-Aug. 2 Quarters later.
PRESSURES—						
Iceland	48	2	4	−60	−24	−6
Ivigtut	42	34	−24	−50	−14	−12
Archangel	30	36	6	−38	14	30
Vardo	47	8	14	−30	10	8
Alaska	24	14	4	16	4	2
Sydney, N.S.	47	16	6	4	14	8
Cent. Siberia †	40	−8	−22	−4	12	−2
Vienna	46	18	8	16	−8	4
Azores	48	−2	−10	26	26	4
Charleston	48	20	−2	2	10	16
Bermuda	48	10	0	16	10	8
San Francisco	51	24	12	8	−30	32
Tokio	42	4	2	36	14	−16
Cairo	56	48	12	50	14	28
Honolulu	42	−32	6	4	−14	−16
N.W. India ‡	50	−12	14	20	16	−14
Port Darwin	44	30	24	20	12	28
Mauritius	50	10	−38	−22	−30	0
Samoa	35	−6	12	2	−16	−6
St. Helena	32	26	16	−2	14	−12
Cape Town	50	16	16	32	2	−14
S. America §	54	−10	−2	8	−26	4
Zanzibar	35	14	12	6	−4	6
Wellington	55	26	−18	−18	−16	24
S. Orkneys	21	−34	−2	50	0	2

* In this and the following tables all coefficients are multiplied by 100.
† Irkutsk + Eniseisk. ‡ Lahore + Karachi. § Santiago + Buenos Aires.

TABLE II.—CORRELATION COEFFICIENTS BETWEEN WINTER TEMPERATURE AT GREENWICH (DECEMBER TO FEBRUARY) AND TEMPERATURES AT OTHER PLACES IN THE TWO PRECEDING, THE CONTEMPORARY, AND THE TWO SUCCEEDING QUARTERS.

PLACE.	Years of Data.	June-Aug. 2 Quarters earlier.	Sept.-Nov. 1 Quarter earlier.	Dec.-Feb. Contemporary Quarter.	Mar.-May. 1 Quarter later.	June-Aug. 2 Quarters later.
TEMPERATURES—						
Greenwich	50	14	8	100	38	8
Valencia	46	−4	14	70	12	8
Stornoway	47	2	8	54	26	10
Vardo	49	20	10	14	18	30
Jakobshavn	30	10	38	−10	16	0
Berlin	49	18	−22	80	34	−8
Godthaab	49	−20	2	−34	−10	−32
Grimsey	49	−16	10	20	14	6
Kristiansund	45	2	−6	40	24	6
N. America *	52	−20	18	20	12	16
Siberia †	40	18	4	34	−6	−2
Dutch Harbour	40	14	36	10	16	−28
Nikolajewsk	28	−18	−48	12	−16	−10
Jakutsk	26	−28	−34	40	−24	−12
Eastern U.S. ‡	50	8	28	4	20	0
Nashville, Tenn.	51	−4	34	4	2	6
Mexico	30	0	44	24	18	−22
Galveston	30	32	26	−16	−12	−10
Arequipa	20	34	28	16	−4	−22
Madras	55	44	22	24	14	46
Batavia	57	42	24	26	32	34
Samoa	34	50	44	52	56	60
Honolulu	30	−6	4	8	4	−20
Mauritius	31	10	8	4	10	−18
Cape Town §	58	32	2	14	26	16
Durban	36	−42	−20	−12	−34	−18
Bulawayo	20	−20	2	32	12	−4
Perth	40	44	10	30	14	18
Adelaide	30	30	18	20	6	12
S. Orkneys	21	2	6	−14	−30	0

* Winnipeg + St. Paul + St. Louis.
† Surgut + Irkutsk + Tomsk.
‡ Charleston + Washington.
§ With March-May before, the coefficient is ·32.

TABLE III.—CORRELATION COEFFICIENTS BETWEEN WINTER TEMPERATURE AT GREENWICH (DECEMBER TO FEBRUARY) AND RAINFALL IN VARIOUS PLACES, AND MISCELLANEOUS DATA, IN THE TWO PRECEDING, THE CONTEMPORARY, AND THE TWO SUCCEEDING QUARTERS.

ELEMENT.	Season.	Years of Data.	June-Aug. 2 Qrs. earlier.	Sept.-Nov. 1 Qr. earlier.	Dec.-Feb. (Contemporary Quarter.	Mar.-May. 1 Qr. later.	June-Aug. 2 Qrs. later.
RAINFALL—							
British Isles . .		42	4	−34	62	30	−20
Peninsula, India .	June-Sept.	49	−28				−16
N.W. India . .	June-Sept.	50	−30				−28
Zanzibar . . .	April	29				16	
S. Rhodesia . .	Oct.-April	27			−4		
Sierra Leone . .	June-Aug.	47	−30				−20
Java	Oct.-Feb.	46			−8		
Samoa . . .	Dec.-Feb.	34			−18		
Cape Town . .	June-Aug.	37	6				10
Havana . . .	May.-Oct.	44	−24				−40
RIVERS—							
Nile flood. . .	July-Oct.	57	−54				−32
Parana . . .	...	33				4	
ICE—							
Greenland . .	April-July	45	10			−10	
Newfoundland . .	Mar.-Aug.	39	−6			30	
Barents . . .	April-Aug.	31	−16			−20	−22
WIND VELOCITY—							
St. Helena . .	...	30	2	−6	6	−8	−10