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VARIATIONS OF PRESSURE DISTRIBUTION

IN THE

NORTHERN HEMISPHERE

DURING THE PERIOD

1904—13

BASED ON TEN-DAY MEANS

BY

C. E. P. BROOKS, D.Sc. AND WINIFRED A. QUENNELL.

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VARIATIONS OF PRESSURE DISTRIBUTION IN THE NORTHERN HEMISPHERE DURING THE PERIOD 1904-1913, BASED ON TEN-DAY MEANS

By C. E. P. Brooks, D.Sc. and Winifred A. Quennell.

On previous occasions we have studied the variations of pressure from month to month in the northern hemisphere by the use of a series of monthly charts showing the deviations of pressure from normal. Two different lines of attack were sought. In the first* the charts were classified into a number of types, and the frequencies with which one type gave place to another were tabulated and compared with the values to be expected on a basis of pure chance; this investigation gave certain suggestions but no results which could be regarded as certain. The second line of research† studied the movements of centres of pressure, i.e., those areas in which the excess of pressure above normal, or the deficit below normal, was at a maximum. This was more fruitful, and demonstrated that the centres tend to follow more or less definite tracks, generally from some westerly towards some easterly point.

Col. E. Gold suggested that further results might be obtained by the use of a shorter interval than one month, and a series of charts‡ was accordingly constructed for the ten years 1904–1913, showing the deviations of pressure for each successive interval of one third of a month, or approximately ten days. The charts were based on the "ten-day charts" included in the North German weather reports issued by the Deutsche Seewarte, which covered the United States and southern Canada, the West Indies and Atlantic north of 30° N., Europe and western Asia as far as 80° E. The average pressure for each interval was read off the charts for a network of points. The normals employed were the means of the corresponding intervals for each of the ten years, smoothed by means of the formula $Nb = (a + 2b + c)/4$, where b is the mean for the interval in question, a that for the preceding interval, c that for the following interval, and Nb the required normal for the interval b.

The charts of pressure deviations obtained from these normals were analysed in the two ways described above as adopted for the monthly charts. The same classification was adopted, but the descriptions of the types and sub-types are repeated here for convenience :—

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* *London, Air Ministry, Meteorological Office, Geophysical Memoirs* No. 31, 1926. Classification of monthly charts of pressure anomaly over the northern hemisphere.

† The variations of pressure from month to month in the region of the British Isles. *London, Q.J.R. Meteor. Soc.*, 52, 1926, p. 263.

‡ These charts are available in MS. at the Meteorological Office.

GROUP I.—PRESSURE AT THORSHAVN ABOVE NORMAL.

IA.—Centre of excess over or near Scandinavia.

IA1.—Excess extending over Iceland, Greenland and the whole or part of the British Isles. Azores near or above normal. Deficit over the Mediterranean.

IA2.—Excess extending from Scandinavia usually to Spitsbergen and north-east Greenland; Mediterranean mainly above normal. Deficit over Azores usually including western North Atlantic; usually a deficit near Lake Baikal.

IA3.—Excess extending from Urals to the British Isles, centred over Scandinavia. Deficits centred over Baffin Bay and Mediterranean; Azores generally below normal.

IB.—Belt of excess from British Isles across Europe.

IB1.—Excess extending across the Azores. Deficit over southern Greenland or Baffin Bay.

IB2.—Excess extending across Greenland and Baffin Bay and including most of the Arctic. Azores usually below normal. This sub-type is not very characteristic.

IC.—Excess centred over the British Isles.

IC1.—Excess extending over western Europe and generally including the Mediterranean. Azores, Baffin Bay and Urals below normal and usually connected by a horseshoe-shaped belt of deficit.

IC2.—Excess extending over Azores. Deficit from Hudson Bay across Baffin Bay to the White Sea or Urals, and extending over most of Arctic.

IC3.—Excess extending over Azores; Baffin Bay above normal. Deficit centred over White Sea or Urals.

IC4.—Excess extending over Iceland and east Greenland. Azores and Urals below normal.

ID.—Excess centred near Iceland or southern Greenland.

(*a*) Pressure above normal at the Azores.

ID1.—Excess extending over the British Isles and the Urals. Deficit over Europe.

[ID2.—Pressure normal or above normal over the British Isles, below normal over the Urals. This sub-type was not represented during the period discussed.]

ID3.—Deficit centred over Europe extending over the British Isles.

(*b*) Pressure below normal over the Azores.

ID4.—Excess extending over Baffin Bay. Belt of deficit extending from south-eastern U.S.A. across Bermuda, the Azores and Europe, generally to the Urals. This sub-type passes into IE.

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ID5.—Excess over Iceland and the Faroes, extending to Scandinavia. Pressure below normal over Newfoundland, Baffin Bay, southern Europe and the Mediterranean.

ID6.—Excess over Iceland extending over Baffin Bay and western Europe ; deficit over Urals.

IE.—Pressure above normal over the Arctic generally ; belt of deficit across the Atlantic and southern Europe in 40°—50° N.

IE1.—Pressure below normal over the Azores. In several examples the belt of pressure deficit extended completely round the world in middle latitudes.

GROUP II.—PRESSURE AT THORSHAVN BELOW NORMAL.

IIA.—Centre of deficit over or near Scandinavia.

IIA1.—Deficit centred over Scandinavia, Finland or the White Sea, extending over Iceland and Greenland, but not necessarily including any part of the British Isles. Excess centred over south-western Europe. The centre of excess lies to the north-east of the centre of deficit in IA1, and the centre of deficit has usually a corresponding shift to the north-east.

IIA2.—Deficit extending from Scandinavia to Spitsbergen and eastern Greenland and also including the Mediterranean. Excess extending from the Azores to Baffin Bay. This type, which is the reverse of IA2, includes few examples.

IIA3.—Deficit extending from Scandinavia over the Urals or Novaya Zemlya, and including part or the whole of the British Isles. Excess over the Mediterranean, excess over Baffin Bay and part or the whole of Greenland. This sub-type is nearly the reverse of IA3.

IIA4.—Deficit extending from Scandinavia over Greenland, Baffin Bay and Spitsbergen, the greater part of Europe and the Mediterranean ; the British Isles generally below normal. Pressure above normal over the Azores. The reverse of this type has not been recognized, so that there is no sub-type IA4.

IIB.—Belt of deficit from British Isles across Europe.

IIB1.—Deficit extending across the Azores. Usually an excess over part or the whole of Greenland. This is very nearly the reverse of IB1.

IIB2.—Deficit extending from south Greenland across the British Isles to the Black Sea. Azores above normal. Generally an excess over the White Sea. This sub-type is much more characteristic than IB2.

IIC.—Deficit centred over the British Isles.

IIC1.—Deficit extending over western Europe and generally including the Mediterranean. Azores and Baffin Bay above normal; belt of excess continuing across Arctic and over or east of the Urals. This sub-type is nearly the reverse of IC1, but the deficit over Europe appears to extend further eastward than the excess in the latter type.

IIC2.—Deficit extending over the Azores. Excess over Baffin Bay, excess over Urals. This sub-type differs from the reverse of IC2 in having the belt of excess from Baffin Bay to the Urals generally broken at Spitsbergen or Vardo.

IIC3.—Deficit extending from the Mediterranean across the British Isles to the north of Canada. Pressure nearly normal over the Azores. Excess centred over the White Sea. This sub-type differs from the reverse of IC3 in that the deficit does not always extend over the Azores. It may therefore be considered as, to some extent, a combination of IIC3 and IIC4; but, as during the period 1873–1900 it includes only seven charts which are otherwise very similar, it was not split up.

IID.—Deficit centred over Iceland or southern Greenland.

(*a*) Pressure below normal over the Azores.

IID1.—Deficit extending over the British Isles and the Urals. Excess over Europe. This is the reverse of ID1.

IID2.—Deficit extending over part or the whole of the British Isles. Excess centred over the Urals. Sub-type ID2 has not been recognised.

IID3.—Excess centred over Europe extending over the British Isles. This is the reverse of ID3.

(*b*) Pressure above normal over the Azores.

IID4.—Deficit extending over Baffin Bay. Belt of excess extending from south-eastern U.S.A. across Bermuda, the Azores and Europe to the Black Sea or Urals. This sub-type is the reverse of ID4 and passes into IIE.

IID5.—Deficit over Iceland and the Faroes. Centres of excess over Baffin Bay, and over Europe. Pressure above normal over the British Isles. The centres of excess lie more to the north-east than the centres of deficit in sub-type ID5.

IID6.—Deficit over Iceland extending over Baffin Bay and western Europe; excess over Urals. This sub-type is the reverse of ID6.

IIE.—Pressure below normal over the Arctic generally; belt of excess across the Atlantic and Mediterranean in about 40° N.

IIE1.—Pressure above normal over the Azores. This sub-type is nearly the reverse of IE1, but the belt of excess tends to lie slightly further south than the belt of deficit in IE1.

The type and sub-type of each ten-day interval is shown in Table I, doubtful or transition types being shown in brackets. In Table II the frequency with which the different types and sub-types occurred during the ten-year period is summarised, winter (October to March inclusive) and summer (April to September) being shown separately.

In Table III is set out the frequency with which each of the main types was followed by the same type and by each of the other types, compared with the frequency to be expected if there is no relation between the weather of one interval and that of the next for winter and summer separately. As with the monthly charts, there is at first sight very little indication of an ordered sequence. Taking a broad grouping first, we find that a chart in group I was followed by another chart in group I on 61 occasions in winter and 46 in summer, compared with expectations of 55 and 44. Similarly a chart in group II was followed by another chart in group II on 48 occasions in winter and 43 in summer, compared with expectations of 43 and 39. There is thus a general tendency for the persistence of the general type from one ten-day interval to the next, the excess over expectation being 11 per cent. in winter and 7 per cent. in summer.

In winter this excess is made up entirely by the persistence of the existing type IA, etc. Of the ten types, eight show a persistence in excess of expectation, the remaining two (IB and IE) are uncommon types in which occurrence equals expectation. The important type IC, excess of pressure centred directly over the British Isles, is especially noteworthy, the number of cases of persistence being 10 compared with an expectation of 5. But as the total number of examples of IC in winter is 30, this means that only one in three persists into the following ten-day interval, so that the persistence is of no value for forecasting.

In summer this persistence of the existing type is not shown; instead the most important feature of the table is a tendency for IA, excess over Scandinavia, to change into ID, excess over Iceland, there being 10 occurrences of this sequence compared with an expectation of 4, but again, as there are 23 occurrences of IA in summer, less than half of these change into ID. Out of the 10 occurrences of ID, 2 are ID4, 2 are ID5 and 5 are ID6.

On a general view the divergences from expectation are too great to be due to pure chance, but not sufficiently great or systematic for use in forecasting.

TABLE I.—TYPES OF PRESSURE DISTRIBUTION—10-DAY INTERVALS.

	January.			February.			March.			April.			May.			June.		
Decades.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1904	IIC2	IIA4	IIC3	IIB1	IIB1	IA1	IA1	IA3	IA1	IID5	IIC3	IB1	IIA3	IIA3	IA2	ID6	IIA1	(IC4)
1905	IC3	IA2	IC3	IC4	IC2	IA1	(IA1)	IIC2	IIC2	(IIA1)	IA3	(IIA1)	IB1	IC3	(IIE1)	IC3	(IE1)	IA2
1906	IIC3	(IIC1)	IIA1	IIA4	IIC1	IIC3	IIA1	IIA1	ID4	IC3	IC3	IIA4	IID4	IIC2	IID2	(ID5)	IA3	IIA1
1907	ID2	IC3	IB2	IA1	IIA4	IC3	IB1	IID6	IC1	IIC2	ID4	IIA1	IIC3	ID4	ID4	IIC3	IID2	IIA3
1908	ID3	IID3	IIA1	IC3	IC2	IIA4	IIC1	IB1	IID4	IA1	ID4	IE1	IIB1	IIE1	IB1	IC3	IID6	IB1
1909	(IB1)	IID6	IC1	IID6	(ID4)	IA3	(ID4)	IIB1	IIB1	IC4	(IIB2)	IIB1	IA3	(ID6)	(IID4)	ID6	IB1	IIB1
1910	IID4	IIA4	IIC1	IID6	IID6	IID6	IA2	(IC2)	IC2	(ID6)	IIB1	IIA4	IID6	IA1	(IID6)	(IIC3)	(IC4)	IIB2
1911	IB2	(IC3)	IC2	IC4	IC1	IID1	IC1	ID2	ID6	ID6	IIA1	(IIB2)	IA3	ID5	IID5	IB1	(ID5)	(IIC1)
1912	(ID5)	IIC2	ID4	IIB1	IA2	(IIC2)	(IIC1)	IID6	(IIA1)	IIA1	IA2	ID2	IC1	IIB2	ID3	IIC1	IIB1	(IIC3)
1913	IID4	IIC3	(IIB2)	IID1	IA3	ID6	IIE1	IIE1	(IIB2)	ID3	IID6	IID6	IIC1	(ID1)	(IIA1)	IID4	IB1	(IB1)

	July.			August.			September.			October.			November.			December.		
Decades.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1904	IIA3	IA2	ID6	IA1	(IID1)	ID1	IA2	ID6	IA1	IID6	IB2	IB2	IC1	IC4	ID4	IIA1	ID4	ID6
1905	(IC4)	ID6	IID6	(IID1)	(IB1)	IA3	(IIE1)	IIA3	ID1	ID6	ID3	ID1	IIC1	ID5	IIE1	IB1	IC3	ID6
1906	IA1	IIA3	IID2	ID6	(IIB1)	IC4	IID3	IA1	IC3	(IIB1)	(IIA4)	(IID6)	IA1	(IIA3)	IC3	IC3	IA1	ID3
1907	IIC1	ID1	ID5	(IIA4)	IIA1	IC2	IID2	IIA1	(IIA1)	IIC3	IIC3	ID3	(IA3)	IB1	IA1	IID2	(IA3)	IA3
1908	ID4	(IIC1)	IB1	IC2	ID4	IIA3	IIA3	(IID4)	IID2	IC1	IA2	IA3	ID5	IC2	IIA3	IC2	IIC3	IA3
1909	IID6	IIA1	IIA4	IC1	(IID4)	IID6	IIA4	IA1	(ID4)	IID2	IID6	(IIA2)	IB1	ID4	IA1	IIC2	ID6	(IID2)
1910	IIB1	ID5	IIB2	IA1	ID6	IIC3	IE1	(IB1)	IIA1	IIA1	ID6	IA3	IIC1	ID3	IA3	(ID4)	IIC3	IIA4
1911	IA3	(IC4)	IA2	IA3	ID5	(IIC3)	IC1	IIA1	IID6	ID1	IC4	IIA4	IIA4	IIB1	(IA3)	IID6	IIB1	IIB2
1912	IID1	IID4	(ID3)	IIC1	(IIA3)	IIB1	ID1	ID4	IE1	IB1	IID4	IIB1	IC1	IC3	IIA3	(IA3)	IIB2	IID4
1913	IB1	IA3	IB1	(IC2)	IA1	IID4	ID1	IIC1	IIC2	ID4	IC1	(IID1)	IIE1	IIE1	IID4	IIA1	IC3	ID6

TABLE II.—FREQUENCY OF TYPES AND SUB-TYPES.

W. = Winter (October to March) S. = Summer (April to September).

Type.	IA		IB		IC		ID		IE		IIA		IIB		IIC		IID		IIE	
Season.	W.	S.	W.	S.	W.	S.	W.	S.	W.	S.	W.	S.	W.	S.	W.	S.	W.	S.	W.	S.
Sub-type. 1	10	9	7	13	8	3	2	6	0	4	8	14	9	8	7	7	3	3	5	3
2	4	6	4	0	7	3	2	1	–	–	1	0	4	5	6	3	3	5	–	–
3	12	8	–	–	11	6	5	3	–	–	3	9	–	–	8	7	1	1	–	–
4	–	–	–	–	4	6	9	8	–	–	9	5	–	–	–	–	6	7	–	–
5	–	–	–	–	–	–	3	6	–	–	–	–	–	–	–	–	0	2	–	–
6	–	–	–	–	–	–	8	10	–	–	–	–	–	–	–	–	11	9	–	–
Total ..	26	23	11	13	30	18	29	34	0	4	21	28	13	13	21	17	24	27	5	3
Per cent. ..	15	13	6	7	17	10	16	19	0	2	12	16	7	7	12	9	13	15	3	2

TABLE III.—SEQUENCE OF TYPES IN SUCCESSIVE 10-DAY INTERVALS, 1904–1913.

(The figures in italics show the anticipated frequency calculated from the total number and the average distribution).

Preceding interval.	Succeeding Interval. IA		IB		IC		ID		IE		IIA		IIB		IIC		IID		IIE	
	W.	S.	W.	S.	W.	S.	W.	S.	W.	S.	W.	S.	W.	S.	W.	S.	W.	S.	W.	S
IA	6	1	2	1	2	3	6	10	0	0	2	3	1	0	4	0	3	4	0	1
	4	*3*	*2*	*2*	*5*	*2*	*4*	*4*	*0*	*1*	*3*	*4*	*2*	*2*	*3*	*2*	*4*	*4*	*1*	*0*
IB	2	2	1	2	3	4	1	2	0	0	0	2	0	1	0	0	4	0	0	0
	2	*2*	*1*	*1*	*2*	*1*	*2*	*2*	*0*	*0*	*1*	*2*	*1*	*1*	*1*	*1*	*1*	*2*	*0*	*0*
IC	4	2	2	0	10	1	5	2	0	1	4	3	0	4	2	0	3	4	0	1
	5	*2*	*2*	*1*	*5*	*2*	*5*	*3*	*0*	*0*	*4*	*3*	*2*	*1*	*4*	*2*	*4*	*3*	*1*	*0*
ID	5	4	0	1	6	1	6	4	0	2	1	6	2	3	4	8	2	5	2	0
	4	*4*	*2*	*2*	*5*	*3*	*5*	*6*	*0*	*1*	*3*	*5*	*2*	*2*	*3*	*3*	*4*	*5*	*1*	*1*
IE	0	1	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	0	*1*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*
IIA	1	6	2	1	5	3	3	1	0	0	4	6	1	2	4	3	1	6	0	0
	3	*4*	*1*	*2*	*4*	*3*	*3*	*5*	*0*	*1*	*2*	*4*	*2*	*2*	*3*	*3*	*3*	*4*	*1*	*0*
IIB	3	3	0	0	2	1	2	3	0	0	1	1	3	2	0	1	2	1	0	1
	2	*2*	*1*	*1*	*2*	*1*	*2*	*2*	*0*	*0*	*2*	*2*	*1*	*1*	*1*	*1*	*2*	*2*	*0*	*0*
IIC	1	1	1	2	0	2	5	5	0	1	5	1	2	1	5	1	2	3	0	0
	3	*2*	*1*	*1*	*3*	*2*	*3*	*3*	*0*	*0*	*3*	*3*	*1*	*1*	*3*	*2*	*3*	*2*	*1*	*0*
IID	6	2	1	4	3	1	1	7	0	0	5	4	2	0	1	4	5	5	1	0
	4	*4*	*1*	*2*	*4*	*3*	*4*	*5*	*0*	*1*	*3*	*4*	*2*	*2*	*3*	*2*	*3*	*4*	*1*	*0*
IIE	0	0	1	1	0	1	0	0	0	0	0	1	1	0	0	0	1	0	2	0
	1	*0*	*0*	*0*	*1*	*0*	*1*	*1*	*0*	*0*	*1*	*0*	*0*	*0*	*1*	*0*	*1*	*0*	*0*	*0*

The second line of investigation was to plot the movements of centres of excess or deficit from one interval to the next. For this purpose the positions of all centres were read off for each interval. When only one centre of excess was present on each of two successive intervals, and the two positions did not differ by more than 90 degrees of arc, the two centres were assumed, *for the purposes of the investigation,* to represent successive positions of the same centre, irrespective of their relative positions. Where more than one centre was present, it was assumed that the two positions nearest to each other represented the successive positions of the same centre. Centres of deficit were analysed in the same way. This arbitrary procedure was adopted in order not to introduce any personal bias into the summaries of prevailing directions of movement, and not because it was considered that two centres shown on successive charts were necessarily related.

The results are shown in Tables IV and V, and graphically in Figs. 1 and 2. Taking all the " squares " together, the percentage frequencies of movements in different directions are as follows :—

	N.	NE.	E.	SE.	S.	SW.	W.	NW.	No movement.	Total.
Centres of excess ..	10	14	30	11	10	5	11	8	1	438
Centres of deficit ..	10	16	22	12	8	10	14	7	1	446

There is a distinct preponderance of movement from west to east, which is more marked with the centres of excess than with the

TABLE IV.—SUMMARY OF DIRECTIONS OF MOVEMENT OF CENTRES OF EXCESS.

Direction of movement.	N.	NE.	E.	SE.	S.	SW.	W.	NW.	No movement.
Lat. N. of 65° *N.*									
Long. 60– 31 W.	–	–	1	–	–	–	–	–	–
30– 1 W.	1	1	8	10	8	1	–	1	–
0– 29 E.	–	1	2	5	3	–	–	–	1
30– 59 E.	–	2	1	1	4	2	3	–	–
60– 80 E.	1	–	–	1	4	2	–	1	–
Lat. 45°–65° *N.*									
Long. 130–121 W.	–	–	4	1	2	–	–	–	–
120– 91 W.	–	–	15	4	1	1	–	–	–
90– 61 W.	–	3	12	4	2	2	2	1	–
60– 31 W.	4	7	14	4	2	1	4	–	–
30– 1 W	7	8	25	6	9	3	8	4	–
0– 29 E.	5	5	10	6	1	7	6	6	–
30– 59 E.	2	6	10	7	3	1	8	6	–
60– 80 E.	4	2	3	–	5	2	11	5	–
Lat. S. of 45° *N.*									
Long. 130–121 W.	1	2	5	–	–	–	–	–	–
120– 91 W.	2	4	9	–	–	–	–	–	–
90– 61 W.	3	4	5	–	–	–	–	–	–
60– 31 W.	2	7	3	–	–	–	1	4	–
30– 1 W.	9	6	3	–	–	1	1	5	–
0– 29 E.	1	3	2	1	–	–	2	2	–
30– 59 E.	–	1	–	–	–	–	1	1	1

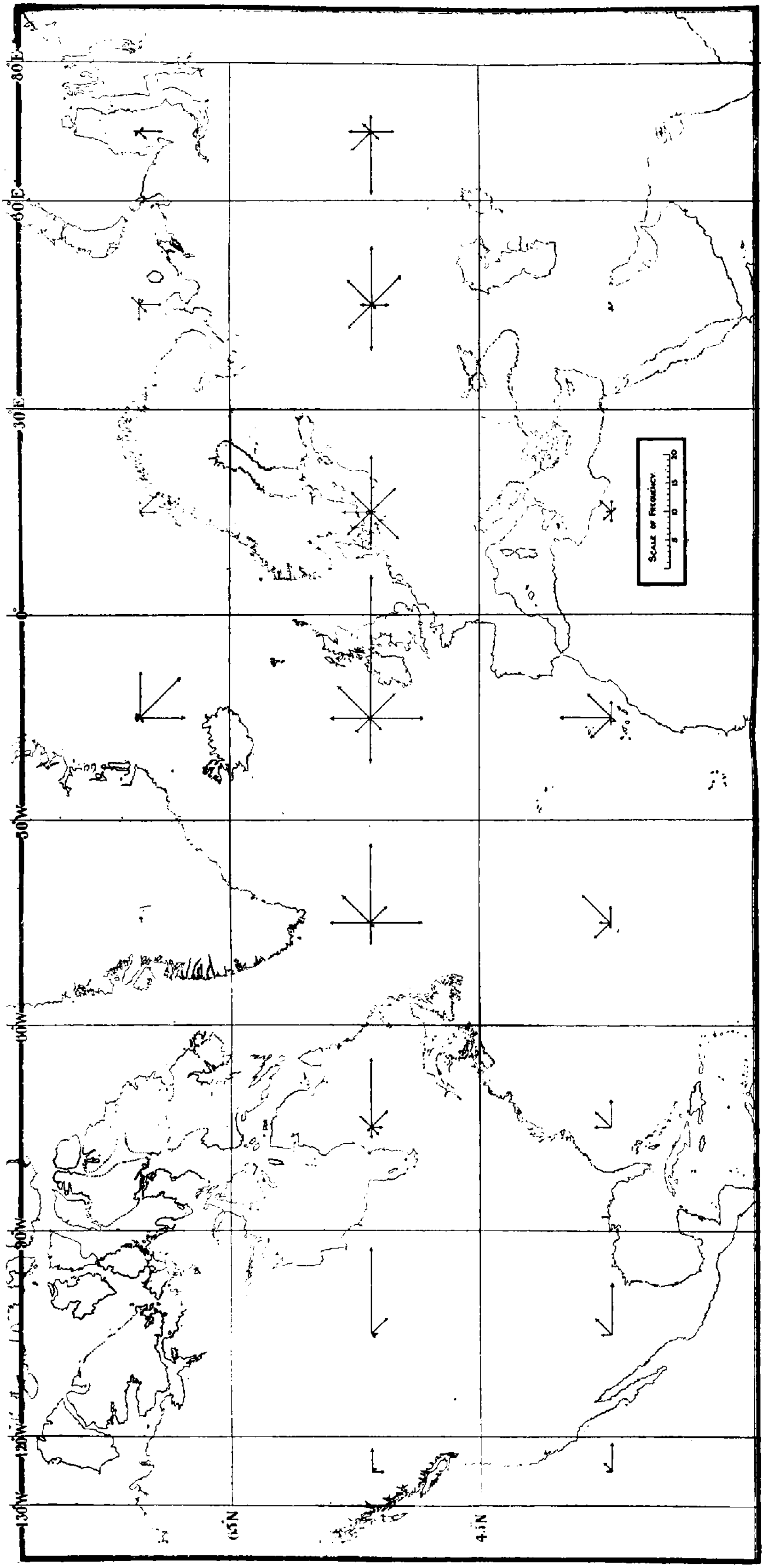

FIG. 1.—Summary of directions of movement of centres of excess.

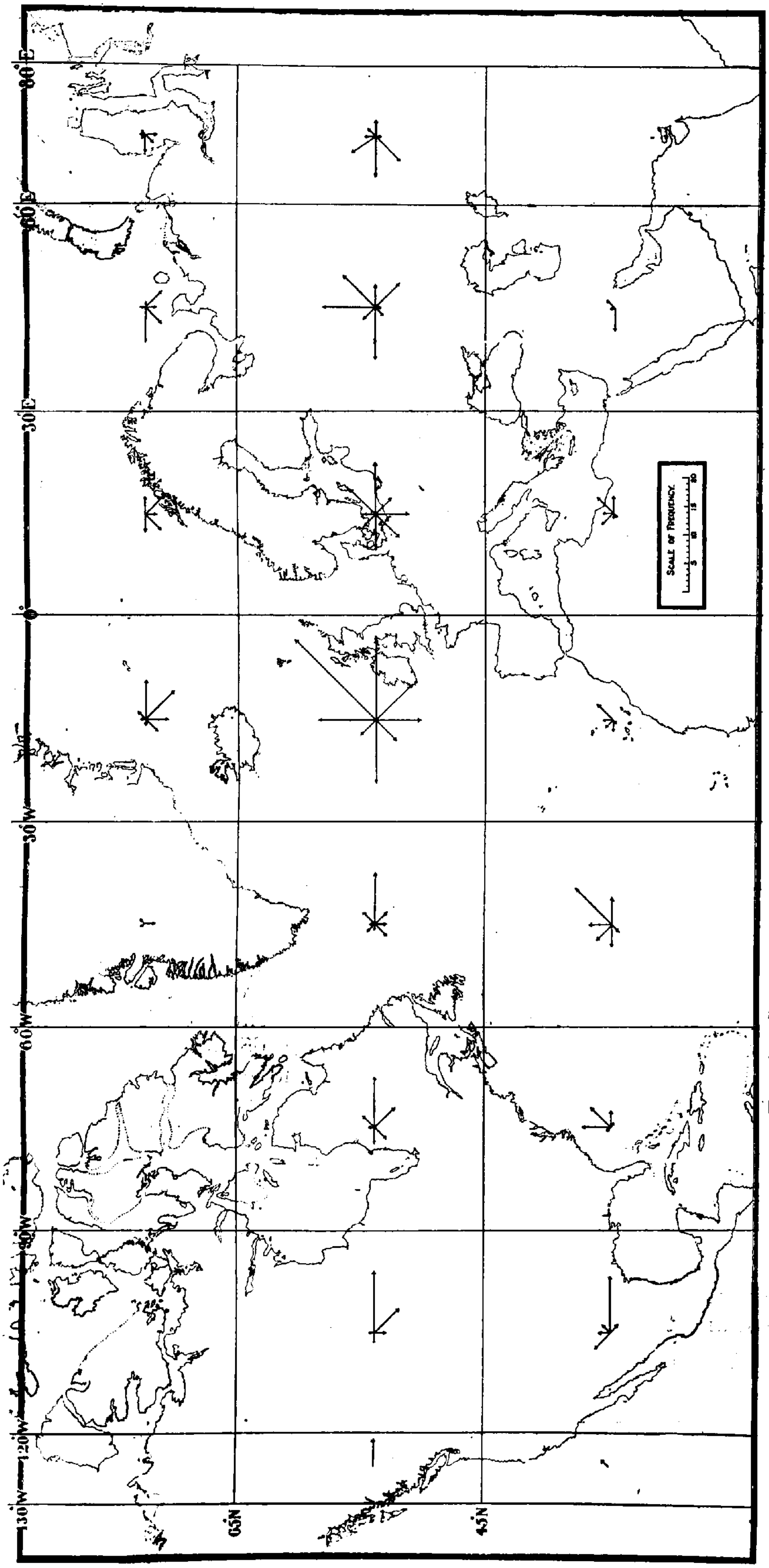

FIG. 2.—Summary of directions of movement of centres of deficit.

TABLE V.—SUMMARY OF DIRECTIONS OF MOVEMENT OF CENTRES OF DEFICIT.

Direction of movement.	N.	NE.	E.	SE.	S.	SW.	W.	NW.	No movement.
Lat. N. of 65° *N.*									
Long. 60– 31 W.	–	–	–	1	2	1	–	–	–
30– 1 W	1	2	7	7	4	3	1	–	1
0– 29 E.	–	–	3	5	2	4	3	–	1
30– 59 E.	1	–	1	4	2	4	6	–	–
60– 80 E.	1	1	–	–	5	2	3	1	–
Lat. 45°–65° *N.*									
Long. 130–121 W.	–	–	5	–	–	–	–	–	–
120– 91 W.	1	–	11	6	2	–	2	–	–
90– 61 W.	1	3	9	5	–	3	3	–	
60– 31 W.	1	3	9	3	2	3	1	2	
30– 1 W.	10	20	14	9	9	5	11	4	–
0– 29 E.	2	6	9	4	6	6	6	3	1
30– 59 E.	9	8	4	6	1	2	9	3	–
60– 80 E.	2	2	3	–	1	6	7	5	–
Lat. S. of 45° *N.*									
Long. 130–121 W.	–	2	–	–	–	–	–	–	–
120– 91 W.	2	2	10	2	–	–	–	4	–
90– 61 W.	5	5	3	1	–	–	–	1	1
60– 31 W.	4	9	5	–	–	2	4	4	1
30– 1 W.	2	4	–	–	–	1	2	2	–
0– 29 E.	2	4	3	–	–	1	1	3	–
30– 59 E.	1	2	–	–	–	–	4	–	–

centres of deficit. Of the former 55 per cent move towards north-east, east or south-east compared with 24 per cent towards north-west, west or south-west ; of the latter 50 per cent towards north-east, east or south-east compared with 13 per cent towards north-west, west or south-west. The tendency for an easterly movement is best marked between 65° and 45° N., west of 0° ; between 0° and 60° E. westerly and easterly movements are equally frequent and east of 60° E. movements towards the west predominate. The movements are most regular over the North American continent ; north of Iceland the movement tends to be south-easterly, and over the Azores and West Africa northerly. Much of this apparent tendency of centres to move towards the middle of the area must however be attributed to the limitations of the charts ; for example a centre moving from Siberia eastwards out of the area covered by the charts would be lost and therefore not counted in the summary.

The distances between the successive positions of centres are summarised in Tables VI and VII, which give the frequencies within various limits in degrees of arc. (A degree of arc is equivalent to 69·1 statute miles.) The most frequent distance is between

TABLE VI.—SUMMARY OF DISTANCES OF MOVEMENT (DEGREES OF ARC) CENTRES OF EXCESS.

Direction of movement.	Distance in degrees of arc. Observed frequencies.						
	1–10	11–20	21–30	31–40	41–50	Above 50	Total.
N. to E.	40	47	27	18	15	27	174
E. to S.	25	59	17	10	4	5	120
S. to W.	19	28	16	1	1	0	65
W. to N.	23	35	13	4	2	0	77
Total	107	169	73	33	22	32	436

TABLE VII.—SUMMARY OF DISTANCES OF MOVEMENT (DEGREES OF ARC) CENTRES OF DEFICIT.

Direction of movement.	Distance in degrees of arc. Observed frequencies.						
	1–10	11–20	21–30	31–40	41–50	Above 50	Total.
N. to E.	38	48	35	17	14	8	160
E. to S.	19	53	17	10	3	2	104
S. to W.	37	38	17	3	2	1	98
W. to N.	21	31	17	8	2	0	79
Total	115	170	86	38	21	11	441

11 and 20 degrees of arc, i.e., about 1,000 miles. This gives an average daily movement of about 100 miles. In the investigation of the centres from monthly charts, it was found that the most frequent displacement from one month to the next was about 2,500 miles, a comparable figure which suggests that the composite entity represented by a centre is on the whole the same in both ten-day and monthly charts. The distance moved was most sharply defined with centres moving towards the south-east, more than 50 per cent having a movement of between 11 and 20 degrees of arc.

Table VIII shows the " life " of the different centres, i.e., the number of successive charts on which the same centre could be identified with some probability. The average " life " of centres, both of excess and deficit, is 40 days, but it frequently happened that centres appeared which could not be identified on previous or subsequent charts ; this was most common with centres of deficit.

TABLE VIII.—LIFE OF CENTRES OF EXCESS AND DEFICIT.

	Duration in 10-day intervals. Observed frequencies.									
	1	2	3	4	5	6–7	8–10	11–13	14–16	17–19
Excess ..	33	28	19	23	16	21	6	6	0	1
Deficit ..	49	40	16	15	11	14	10	8	2	1

The general result of the investigation is to confirm the results previously obtained from the use of monthly charts of pressure deviations. It appears probable that the " centres " are in general real entities, especially the centres of excess ; though some of the latter, and more of the centres of deficit, are probably "accidental" in the sense that they are fortuitous results of the summation of daily charts. Thus a centre of deficit might be produced either by a single depression travelling slowly along a looped path, or by a series of depressions converging on a small area, but it is not clear that the two phenomena are necessarily of the same nature.

It is hoped to carry out a closer analysis of the movements of individual centres later.

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