551.524.2(410):551.524.32

Meteorological Office

British Climatological Branch Memoranda, No. 2

Maps of Standard Deviation of Monthly Mean Temperature, 1921-50

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Introduction

It is customary to assess the character of the weather during a month by the departures from the long-period averages of the main elements. Departures from average of the monthly mean temperature, usually derived from $\frac{1}{2}$ (mean daily maximum + mean daily minimum), are published in the Monthly Weather Report and also in the Monthly Summary to the Daily Weather Report. If for any particular station the monthly mean temperature and its departure from the long-period average are given it is not always easy to assess the extent to which the month has been unusual in respect of temperature. To do this with any precision it is useful to know the frequency with which any given departure from average is likely to occur and for this an estimate of the variance of the monthly means about the long-period average is required.

If the standard deviation of the mean temperatures for any month is σ then, assuming a normal distribution it can be said, for example, that more than 95% of the months of that name will have mean temperatures which lie between -2σ and $+2\sigma$ on each side of the average. Thus if σ for January is 3.0°F at a station, then the probability of a single January being 6.0°F or more colder than the average is less than $2\frac{1}{2}$ per cent, i.e. on the average a January as cold as this would occur only once in about 43 years. At another station where the January standard deviation is 4.0°F, the same departure from average would be equalled or exceeded on the average once in about 15 years and would be correspondingly less noteworthy.

Thus a knowledge of the distribution of the standard deviation of monthly mean temperature over the country is of importance in judging the significance of any given departure from average especially if, as will be shown, it varies quite appreciably from one place to another and in different months of the year.

Values of the standard deviations for each month have been computed for 52 stations with records covering the standard period 1921-1950, thus providing a reasonably good network over Great Britain and Northern Ireland. These values may be used in conjunction with the published temperature averages for the same period.[1] They are presented in the form of maps on which the individual station values are plotted and on which isopleths at intervals of half a degree F. have been drawn in.

Stations used

The 52 stations used were as follows (3 stations in Eire were included to assist in drawing the isopleths over Northern Ireland):-

Station	Height, ft.	Station	Height ft.
Aberdeen	79	Markree Castle	122
Armagh	205	Marlborough	424
Birmingham (Sparkhill)	425	Nottingham	192
Braemar	1,111	Oxford	208
Cambridge	41	Portland Bill	32
Cardiff	203	Porton	363
Cockle Park	325	Plymouth (The Hoe)	117
Colmonell	170	Renfrew	29
Cullompton	202	Rothamsted	420
Douglas	284	Ross-on-Wye	223
Dublin (Glasnevin)	55	St. Ann's Head	142
Dungeness	20	Scilly	163
Durham	336	Shaftesbury	680
Edinburgh	441	Sheffield	428

Station	Height, ft.	Station	Height, ft.
Eskdalemuir	794	Southampton	65
Felixstowe	10	Southport	35
Fortrose	69	Spurn Head	29
Gorleston	5	Stonyhurst	377
Holyhead	26	Stornoway	11
Keswick	254	Tiree (1927-50)	29
Kew	18	Tynemouth	108
Lerwick	269	Ventnor	60
Leuchars	33	Welshpool	13
Liverpool (Bidston)	198	Wick	119
Malin Head	84	Wisley	150
Manchester (Whitworth Park)	125	York	57

Discussion

It will be seen from the maps that in all months the standard deviations are smaller on the coasts than they are inland, showing the effect of the sea in reducing the climatic variability. There is also an appreciable variation during the year, values being about twice as great in winter as they are in summer. Over the 30-year period considered January and February are, on the whole the most variable months, standard deviations being highest in January over Scotland and Northern Ireland and in February over England and Wales. The high February values may be partly due to the inclusion in the period of the outstandingly cold February of 1947 and partly because of the shorter month. The month showing least variability in most places is May but June has the lowest values over parts of the Midlands and south-east England and July in a coastal strip from Aberdeen to Felixstowe. There is evidence of a marked change in the distribution between February and March, a shifting northwards of the region of maximum variability, so that over Scotland March is not very different from February. In order to bring out the differences between Scotland, England and Wales and Northern Ireland Table I has been compiled. This gives estimates of the average variability, expressed as a standard deviation, in each month over each of the three countries. They were obtained by reading off values from the maps at points on a suitable grid (20 points over England and Wales, 10 over Scotland and 3 over Northern Ireland), squaring them to obtain the variances and taking the square root of the average variance over each country.

Table I - S.D. of Monthly Mean Temperature, °F. - General Values.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
England and Wales	3.3	3.5	2.5	2.2	1.6	1.8	1.9	1.9	2.1	1.9	2.2	2.9
Scotland	3.0	2.9	2.9	2.1	1.5	1.9	1.6	1.7	1.9	1.8	2.0	2.7
Northern Ireland	2.7	2.6	2.4	2.3	1.3	1.7	1.6	1.7	1.7	1.6	1.9	2.5

The table confirms that May is in general the least variable month as regards temperature although over Scotland July runs it fairly close. February is the most variable month in England and Wales but in the other two countries January leads, although in Scotland February and March are not far behind.

The main use which can be made of these standard deviations has been mentioned in the introduction. Table II, based on the normal distribution, gives the probabilities, corresponding to various values of the standard deviation, that any particular departure from average will be equalled or exceeded. They are expressed as the number of occasions in 100 years.

Table II - Probability that given departures from average will be equalled or exceeded: number of occasions in 100 years.

Standard Deviation	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0 °F.
Departure from Average °F. plus or minus	No. of occasions in 100 years									
1.0	2.3	16	25	31	34	37	38	40	41	42
2.0	0.0	2.3	9	16	21	25	28	31	33	34
3.0	0.0	0.1	2.3	7	11	16	19	22	25	27
4.0		0.0	0.4	2.3	5	9	13	16	19	21
5.0			0.0	0.6	2.3	4.8	8	10	13	16
6.0			0.0	0.1	0.8	2.3	4.3	7	9	11
7.0				0.0	0.3	1.0	2.3	4.0	6	8
8.0				0.0	0.1	0.4	1.1	2.3	3.8	5
9.0					0.0	0.1	0.5	1.2	2.3	3.6
10.0						0.0	0.2	0.6	1.3	2.3
11.0						0.0	0.1	0.3	0.7	1.4
12.0							0.0	0.1	0.4	0.8

Suppose, for example, that it is required to know the chance in January of a mean temperature which is 4.0°F or more below the average at Oxford. The standard deviation is seen from the January map to be 3.8°F and looking along the row for 4.0°F it is seen that such a departure will be equalled or exceeded about 15 times in 100 years. At Wick, where the January standard deviation is only 2.1°F, the same departure can be expected to be equalled or exceeded only two or three times in 100 years. The mean monthly temperature at Oxford in August, 1947 was 4.8°F above average. The August standard deviation is 2.1°F and the table shows that the chance of such a hot August is only about one in one hundred.

The maps can also be used in connection with the calculation of approximate averages of accumulated temperature above or below any desired base temperature by a statistical method due to Thom.[2]

Acknowledgement

It is a pleasure to acknowledge the assistance given by Miss J.M. Scott and Mrs. M. Mayne who extracted the data and carried out most of the computations on which the maps presented in this memorandum are based.

References

1. Met. Office, London: Averages of Temperature for Great Britain and Northern Ireland, 1921-50. M.O.571, 1953.

2. H.C.S. Thom: Normal degree days below any base. Mon. Weath. Rev. Washington D.C., 82, 1954, p. 111.

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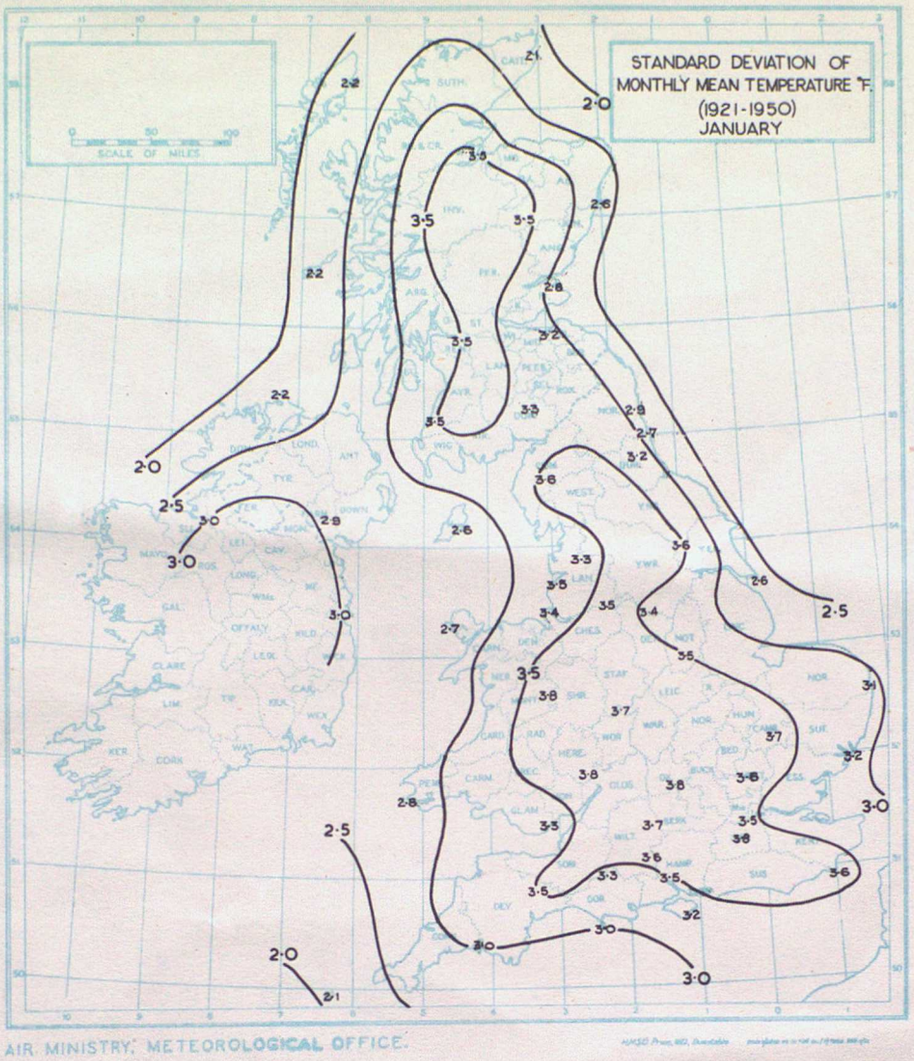
2·2 (Lerwick)



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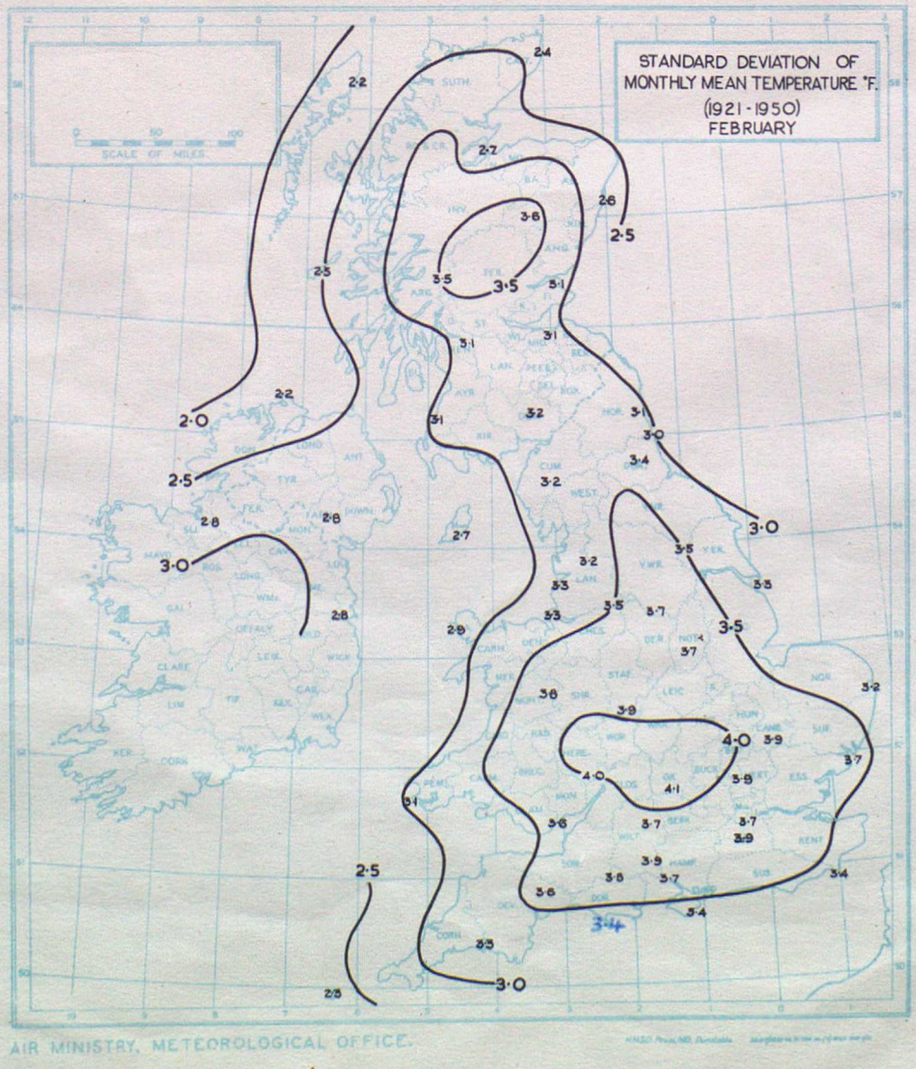

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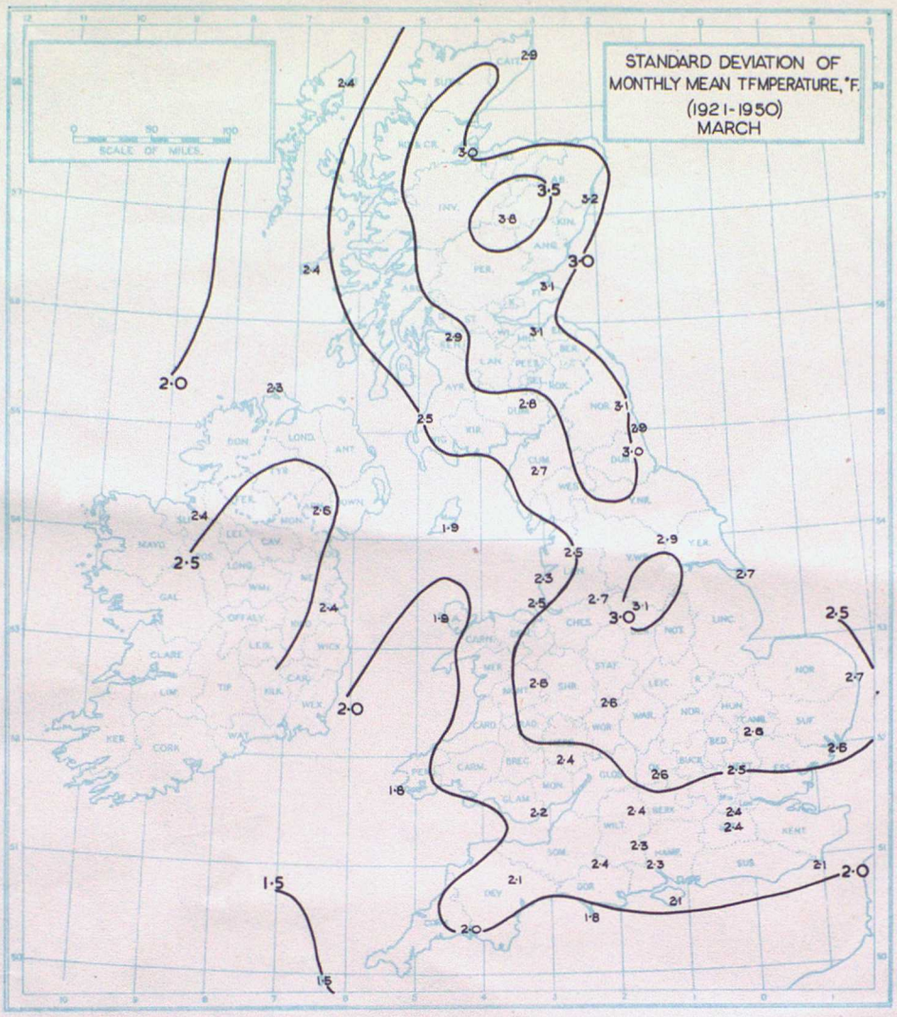

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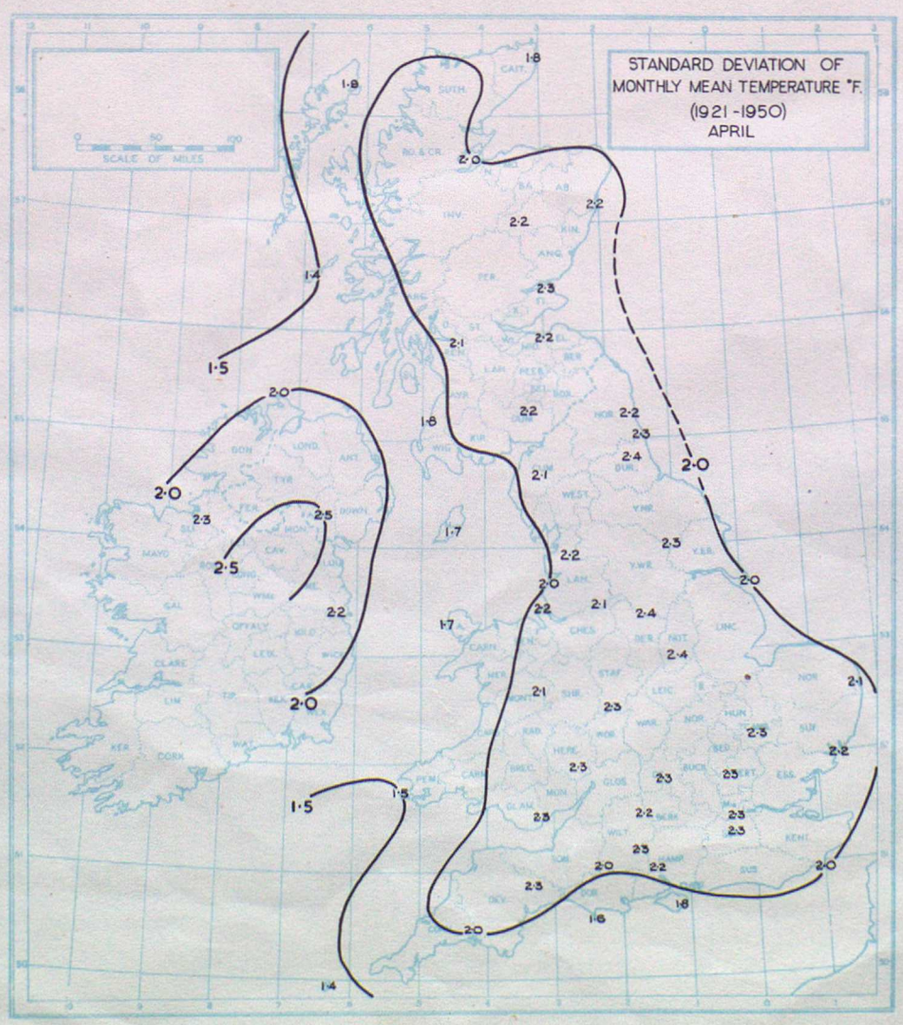

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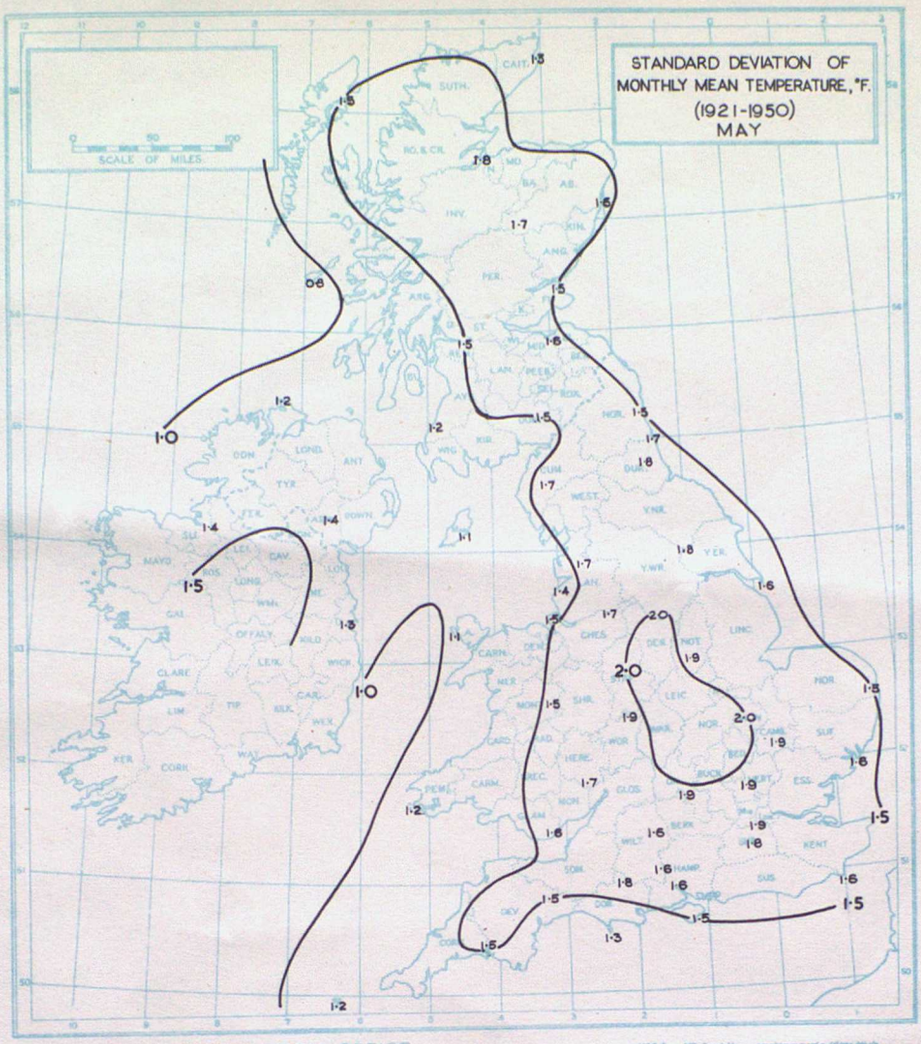

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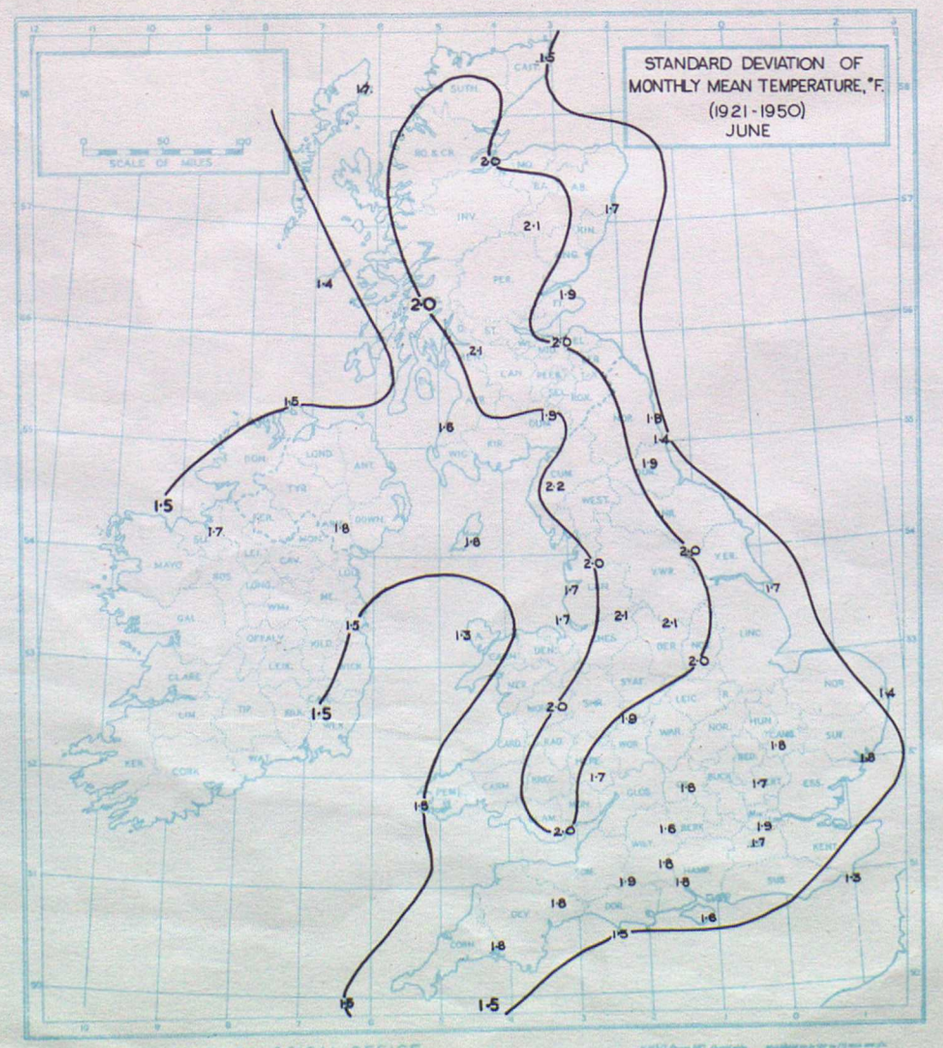
↑1·9 (Lerwick)



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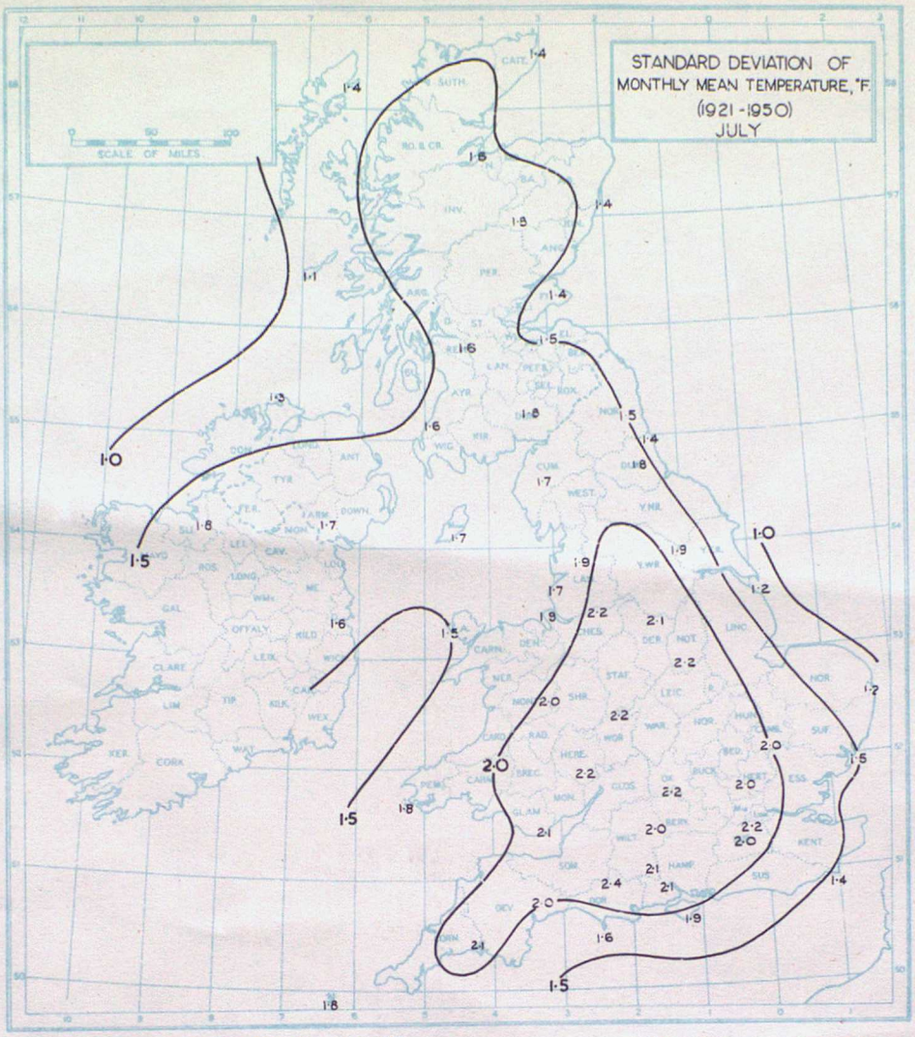

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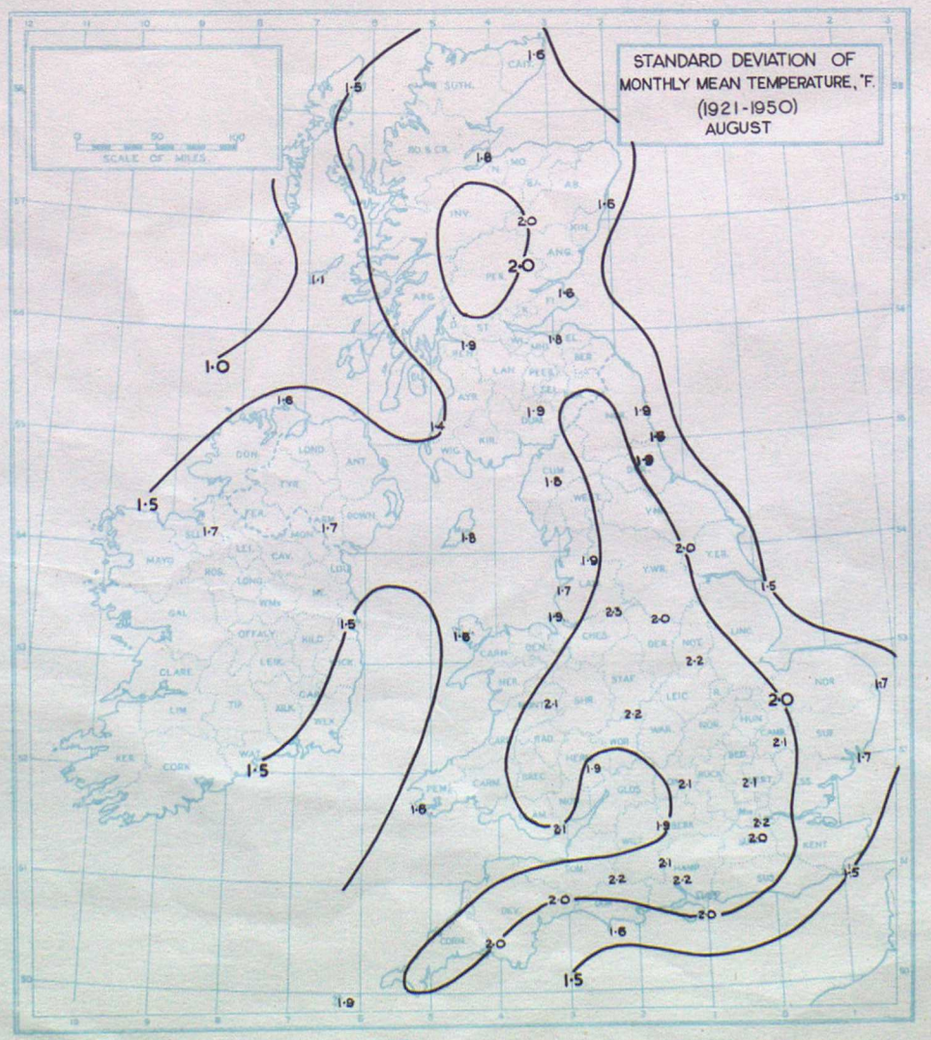

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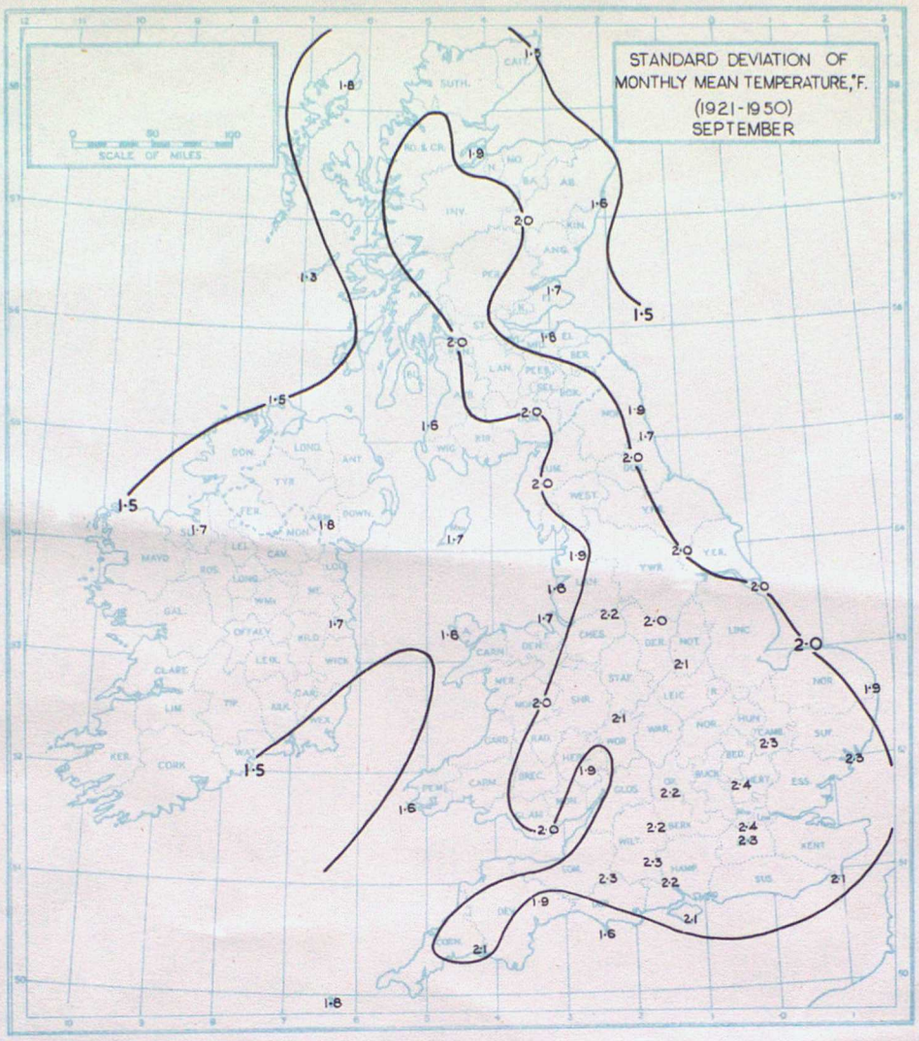

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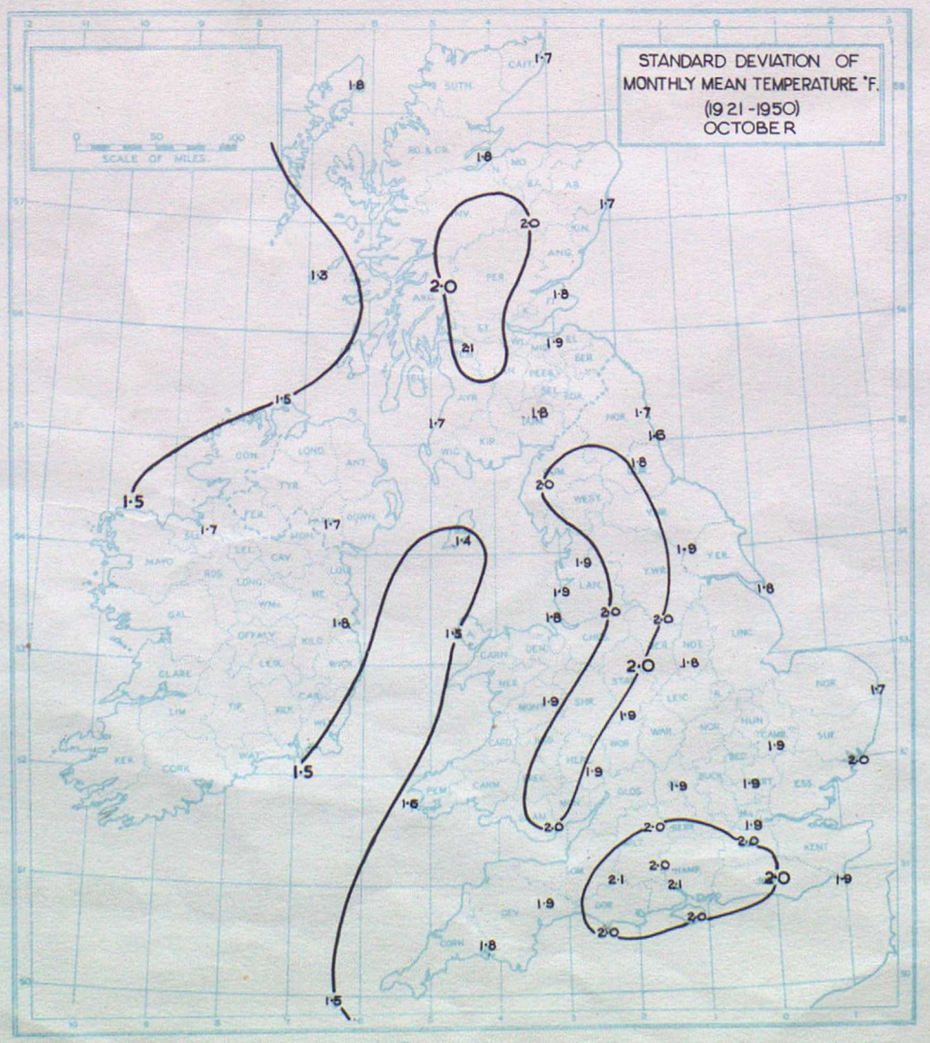

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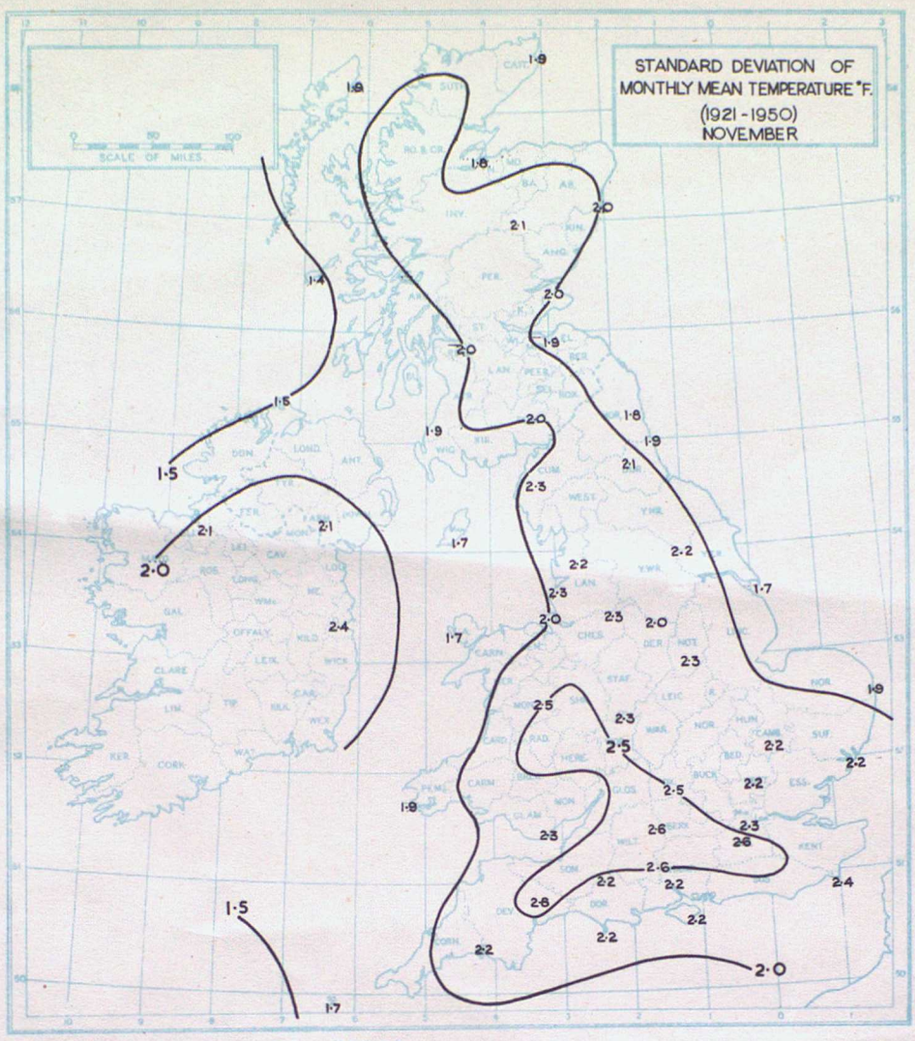

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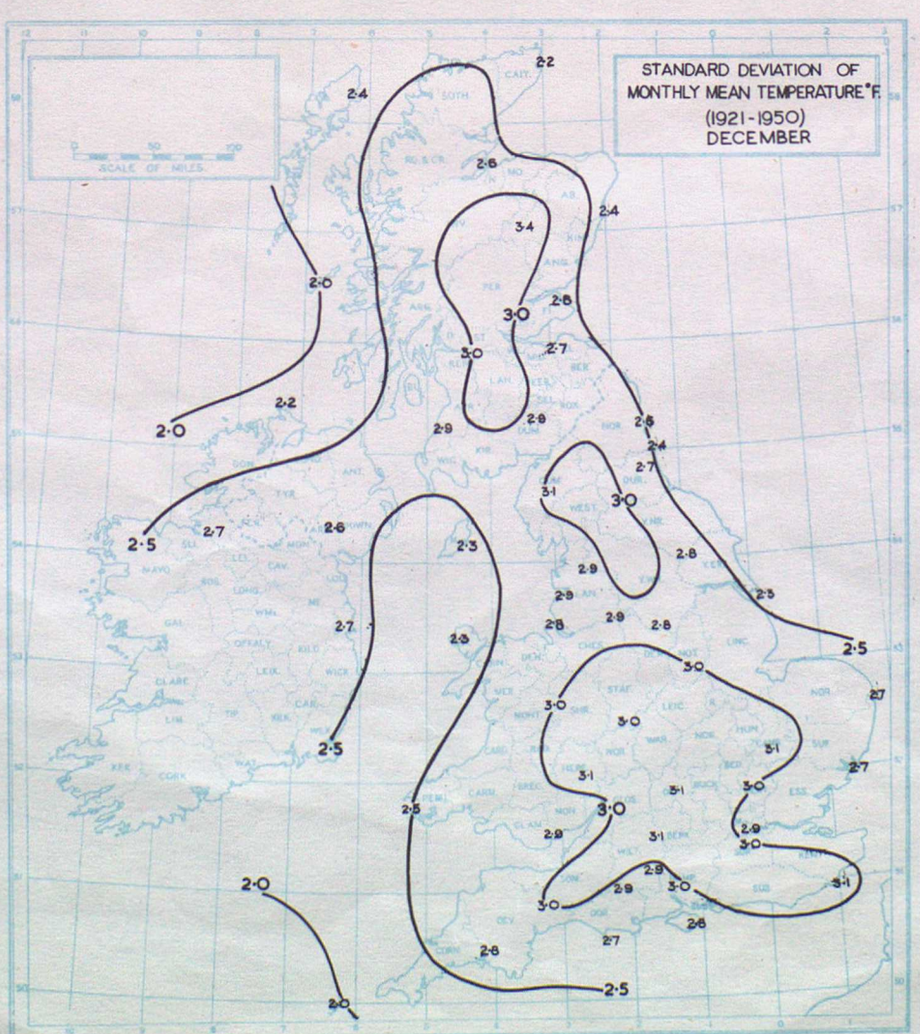
↑2·3 (Lerwick)



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