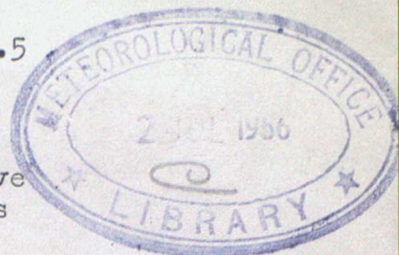


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Monthly averages of accumulated temperature above and below various base temperatures for stations in Great Britain and Northern Ireland, 1921-50

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Introduction

Accumulated temperature is defined as the integrated excess or deficiency of temperature with reference to a fixed datum, usually called the base temperature, over an extended period of time. Accumulated temperatures with a base temperature of 42°F are of special interest for agriculture, the view that this is the critical temperature above which plant mences and is maintained in a European climate. For the study of cooling problems, however, engineers are concerned with temperatures below or above base temperatures in the region of 60°F . In this country a base temperature of 60°F has been adopted for the heating problems, it having been shown experimentally that for continuously heated to an internal temperature of 65°F there is quite a close relation between the amounts of fuel consumed and the accumulated temperatures below 60°F taken over corresponding periods of time. In American practice, where higher inside temperatures are aimed at, the base temperature usually adopted is 65°F . Heating engineers generally refer to accumulated temperatures as "degree-days" but strictly speaking the degree-day is the unit in which accumulated temperature is usually expressed.

Averages of accumulated temperature may be derived in a number of ways. Ideally, accurate daily values would be obtained from continuous temperature records, or at least from observations made once hourly; these would then be summed to give monthly values and, given a sufficiently long record, these in turn would be used to compute long-period averages. In practice, daily values are usually evaluated using the method of Meteorological Office Form 3300 - "Tables for the Evaluation of Daily Values of Accumulated Temperature above and below 42°F from Daily Values of Maximum and Minimum Temperature". The tables can be used for base temperatures other than 42°F by first suitably adjusting the observed temperature extremes. Daily values obtained in this way may then be combined, as indicated above, to give long-period average monthly values. Averages of accumulated temperature above and below 42°F for 28 selected stations and for the period 1931-1948, computed in this way, have recently been published,¹ but a good deal of laborious calculation is involved. Earlier averages of accumulated temperature with respect to base 42°F were computed on a weekly basis using weekly means of daily maximum and minimum temperature by the use of formulae due to Strachey² but the latest period for which they are available is 1927-26. Accumulated temperatures with respect to any other base have not been computed on a routine basis in the Meteorological Office although daily maximum and minimum temperatures for 14 representative stations have been regularly supplied for some years to the Gas Council who have computed from them monthly accumulated temperatures below 60°F , using the method of Form 3300, and published the results in the form of duplicated monthly reports. These Gas Council figures could be used to compute averages but the period covered is only about 10 years and the number of stations very limited.

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Various methods have been suggested or applied by a number of writers to obtain accumulated temperature averages from monthly mean temperatures or even from long-period average values of monthly mean temperature. Thus Gregory³ has used averages of monthly mean temperature 1881-1915 to compute averages of accumulated temperature above 42°F and Dufton⁴ has used the temperature averages for the same period to compute averages of accumulated temperature below 60°F. The results cannot be regarded as satisfactory, however, particularly for months in which the mean temperature is not far removed from the base temperature. In such a case the use of the average monthly mean gives a small or even zero accumulated temperature when it is obvious that on some days the temperature will have been well below, or above the base temperature for part, if not all, of the time.

Another possible method of computing averages would be to apply the method of Form 3300 using individual monthly values of mean daily maximum and minimum temperature. This more detailed process would clearly be an improvement on any method using average temperatures only because it would take some account of temperature variability. Yet another method is that due to H.C.S. Thom⁵ which by using the standard deviation of monthly mean temperature as well as the long-period average enables a statistical estimate to be made of the additional degree-days in months when use of the average temperature alone would indicate the accumulated temperature to be small or zero. This method has been used in this memorandum and its use is justified by the comparison of results obtained by the various methods referred to above which are given in Tables I and II. Table I shows monthly and annual averages of accumulated temperature above 42°F for Rothamsted, 1931-1948 computed by six different methods and Table II shows monthly and annual averages below base 60°F at Kew Observatory, 1950-54 similarly computed. In each case method 1 is the method based on daily values, the figures in Table I being taken from the daily reports and those in Table II from the monthly reports issued by the Gas Council. It is clear that only methods 2, 3 and 6 give comparable results, and of these 6, which is Thom's method, is clearly better than 3 and slightly better than 2. Given the standard deviations of monthly mean temperature, and these are now available for a network of stations in the British Isles⁶, it is also easier to apply than method 2.

Method used and stations selected

Thom's expression for the calculation of average monthly accumulated temperature in degree-days below any base b is

$$\bar{D} = N(b - \bar{t} + 1 \sqrt{N} \sigma_m)$$

where N is the number of days in the month, b is the base temperature and \bar{t} the average monthly mean temperature in °F, 1 is a parameter obtained from a table of 1 against h where $h = b - \bar{t}$, and σ_m is the standard deviation of the monthly mean temperatures. The relation between 1 and h was established empirically by Thom and shown to be independent of climate and season over the United States. It is therefore fair to assume that the relation will also apply over Great Britain. It can be shown that if averages of accumulated temperature above base b are required then the above expression becomes

$$\bar{D} = N(\bar{t} - b + 1 \sqrt{N} \sigma_m)$$

The stations used are those for which values of σ_m and \bar{t} are available for the standard period 1921-50.^{6,7} They are 49 in number and the computed averages in degree-days below bases of 70°F, 60°F, 50°F and 42°F and above bases of 42°F and 60°F are presented in Tables III to VIII respectively. Station details (latitude, longitude and height) are given in Table III only.

Map of Average Accumulated temperature below 60°F.

A requirement has been stated by the Building Research Station for the publication in map form of annual averages of accumulated temperature below a base of 60°F. A map has the advantage of presenting the information in a convenient and easily assimilated form, but there are difficulties in drawing a map based on station level averages because of the considerable effects of altitude. Just as average temperature decreases with altitude at a rate of about 1°F. in 300 feet, so average accumulated temperature below 60°F increases with altitude at a substantial rate. For example Hampstead (450 feet) has an annual average which is about 12% greater than that for Kew Observatory (18 feet) while Buxton (1007 feet) has an annual average 15% greater than that at Macclesfield (500 feet). Thus the map will show the effects of relief quite strongly and will become more complicated as the number of station values is increased, or as appropriate allowances are made for height variations. Nevertheless, an attempt has been made to prepare such a map and it is presented in Fig.1. It shows the broad-scale features of the distribution over the country of annual average accumulated temperature below 60°F for the period 1921-50. As the values for 49 stations given in Table IV were considered too few for the purpose additional values were calculated for most of the remaining stations for which temperature averages 1921-50 are available, the required standard deviations of monthly mean temperature being interpolated from the maps in reference 6. To fill some obvious gaps in the network a number of additional temperature averages were computed and weighted to the standard 30-year period. The final map is based on data from 162 stations the positions of which are indicated by dots. Monthly averages of accumulated temperature are also available for each of these stations but they are not reproduced here.

As previously mentioned the values depend to a considerable extent on altitude and thus the isopleths in Fig.1, drawn at intervals of 500 degree-days, tend to follow the ground contours. With a rather limited station network and such a relatively small-scale map, however, only the larger scale topographical features could be taken into account in drawing the map and it can only be regarded as giving a general picture of the distribution. The average annual number of degree-days below 60°F. varies from just under 3,000 in the extreme south-west of England to 6,000 and over at levels above 1,000 feet in central Scotland, with values of 5,000 and over near sea-level in the north of Scotland and the Shetlands. It is probable that the summit of Ben Nevis would have an annual average of rather more than 10,000 degree-days below 60°F - based on the available averages for the period 1884-1903.

In using Fig.1 there is a danger that values may be interpolated for places which, owing to local topographical features, are at an appreciably different altitude from the nearest meteorological stations used in preparing the map. For example a value of about 4,400 would be interpolated for the Sheffield area but this would be too low for a place on the higher ground to the west of the city and too high for the city itself; the actual value for the Sheffield climatological station is 4,170 and this comparatively low value probably reflects the warming effect of the built-up area.

When preparing average temperature maps it is customary to first reduce the station values to mean sea level by adding a correction of 1°F. for each 300 feet of altitude. This simplifies the resulting map by eliminating the effects of altitude but it must be remembered that in using the map to interpolate values for a specific place, a reverse correction must be applied, depending on the altitude of the place. The same thing can be done for accumulated temperature and Fig.2 shows the distribution of average annual accumulated temperature below 60°F. computed by Thom's formula after first reducing the temperature averages for the 162 stations to m.s.l. The pattern is considerably less complicated than that of Fig.1, although isopleths at intervals of 250 are drawn; the main features remaining are the general increase from less than 3,000 degree-days in the extreme south-west to 5,000 or over in the extreme north and the tendency for higher values as one goes inland from the coasts. It is considered that Fig.2 can be used to interpolate

average values for places at or near sea level, probably up to about 100 feet, without serious error. Unfortunately there is no simple way of applying a correction for altitude as in the case of average temperature because the correction is not simply related to altitude. Comparison between the station level and sea level values which have been computed suggests that for annual averages the correction ranges from about 1.0 degree-days per foot in southern England to about 1.2 degree-days per foot in southern Scotland and the Shetlands. Thus the addition of 365 degree days for every 300 feet increase in altitude (just over 1.2 degree-days per foot) is too large a correction except in those months when the mean temperature is well below the base temperature or in the extreme north, where even the summer monthly mean temperatures are sufficiently far below 60°F. A more accurate method of estimating accumulated temperature averages for a place which is neither near sea level nor near a meteorological station is described in the next section.

Estimation of averages of accumulated temperature below 60°F.

Suppose that it is desired to estimate the average accumulated temperature below 60°F. for each month at a place whose altitude is h feet. Thom's expression for the monthly degree-day average is

$$\bar{D} = N(60 - \bar{t} + 1.1 \sqrt{N} \sigma_m)$$

By using published maps of average daily mean temperature^{8,9} monthly values of $(t + h/300)$ °F. can be obtained. Hence values of \bar{t} °F. can be calculated subtracting the altitude correction $h/300$. Similarly monthly values of σ_m can be read off from the maps of reference 6. Curves have been drawn relating \bar{D} with \bar{t} for various values of σ_m and for $N = 31$ and are reproduced in Fig. 3. Similar curves for $N = 30$ are given in Fig. 4. Thus, if in July $t = 57.5$ and $\sigma_m = 2.2$ it can be seen from Fig. 3 that \bar{D} , the average accumulated temperature below 60°F, is about 118 degree-days. Similarly the values for the other 31 months can be obtained from Fig. 3 and those for 30-day months from Fig. 4. In the case of February and all other months with \bar{t} less than 40°F. the required value is simply $N(60 - \bar{t})$. The monthly estimates can then be summed to give the required seasonal or annual values.

Example. Estimate the average annual accumulated temperature below 60°F. at Askrigg, Yorks, altitude 750 feet. The altitude correction for temperature is $750/300 = 2.5$ °F. Using the maps of references 9 and 6, respectively, the following monthly values of \bar{t} (map value -2.5°F.) and σ_m are obtained. The corresponding values of \bar{D} are thence obtained by the method just described. They are equal to $N(60 - \bar{t})$ for the months December to March and are read off from Figures 3 or 4, as appropriate, for the remaining months.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
\bar{t}	36.0	36.4	39.5	43.6	49.6	53.4	58.3	57.0	52.9	46.4	40.3	37.3
σ_m	3.7	3.5	3.0	2.4	1.9	2.1	1.9	2.0	2.1	2.1	2.3	3.1
\bar{D}	744	667	635	492	322	208	94	123	221	422	591	704

The sum of the twelve monthly values of \bar{D} is 5223 degree-days, which is the average value required. It is of interest to note that interpolation from Fig. 1 would have given a value of something over 5,000 while Fig. 2 would give a m.s.l. value of about 4,450 and, assuming an altitude correction of 1.1 degree-days per foot, this would give a station level average of $4,450 + 825 = 5,275$ degree-days.

Probable effects of local climate variations

Mention has already been made of urban effects. These may raise the average temperature of a city by 1 or 2°F. above that of the surrounding area. This corresponds to a decrease of from 300 to 600 or of some 7 to 15%, in the average number of degree days per annum below 60°F. The effect of altitude has been taken into account but only as far as temperature is concerned. Higher sites will in general also have higher wind speeds and this will mean that average

fuel requirements may be higher than is indicated by the average accumulated temperature. The effects of local temperature variations between sites having different aspects and exposures are not likely to be very large. For example, although an enclosed valley will have appreciably lower night minimum temperatures than a hill-top nearby, it will also have appreciably higher day maxima and the mean temperatures of the two sites will tend to be much the same. Similarly, the main effects of woods or of adjacent deep water are to decrease the diurnal range of temperature leaving the mean values little changed.

References

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TABLE I. Averages of accumulated temperature above base. 42°F. at Rothamsted, 1931-48, computed by six different methods

Method	1	2	3	4	5	6
January	36	12	0	0	0	53
February	40	17	6	3	0	62
March	98	70	53	34	0	115
April	177	162	162	138	131	165
May	319	307	304	305	304	304
June	474	471	471	471	471	471
July	593	592	592	592	592	592
August	589	589	589	589	589	589
September	441	438	438	438	438	438
October	246	225	223	222	223	226
November	100	68	78	43	33	87
December	47	18	9	6	0	59
Year	3,160	2,969	2,925	2,841	2,781	3,161

1. Using daily values of maximum and minimum temperature.
2. Using monthly values of mean daily maximum and mean daily minimum temperature.
3. Using average monthly values of mean daily maximum and mean daily minimum temperature.
4. Using monthly values of mean daily mean temperature $\left[\frac{T}{2} (\text{max.} + \text{min.}) \right]$
5. Using average monthly values of mean daily mean temperature.
6. Using average values of mean daily mean temperature and standard deviation of monthly mean temperature.

TABLE II. Averages of accumulated temperature below base 60°F. at Kew Observatory, 1950-54, computed by six different methods

Method	1	2	3	4	5	6
January	638	638	637	638	637	637
February	563	566	567	566	567	567
March	498	498	498	498	498	498
April	378	371	372	371	372	372
May	204	182	180	161	161	171
June	88	68	57	22	0	57
July	43	35	34	2	0	37
August	49	39	39	0	0	50
September	133	118	118	94	93	132
October	272	266	267	266	267	267
November	437	437	438	437	438	438
December	567	570	570	570	570	570
Year	3,870	3,788	3,777	3,625	3,603	3,796

N.B. The six methods are as detailed beneath Table I.

TABLE III. Averages of Accumulated Temperature below 70°F. (in degree-days) at 49 stations, period 1921-50

Station	Lat.	Long.	Height	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
	° 'N	° 'E	feet													
Lerwick	60 8	1 11W	269	986	906	961	855	756	615	511	511	582	747	840	936	9206
Wick	58 27	3 5W	119	964	872	911	810	725	570	477	480	537	694	810	915	8765
Fortrose	57 35	4 8W	69	970	867	874	738	623	459	363	384	486	676	828	936	8204
Stornoway	58 13	6 20W	11	915	833	868	774	676	528	443	443	522	679	786	874	8341
Aberdeen	57 10	2 6W	79	970	869	896	780	679	489	384	412	504	681	822	927	8413
Braemar	57 0	3 24W	1111	1119	999	1001	870	735	540	446	490	600	803	960	1070	9633
Leuchars	56 23	2 53W	33	989	878	880	750	648	456	357	384	480	670	834	949	8275
Edinburgh	55 55	3 11W	441	973	881	890	765	648	453	356	384	483	670	816	927	8246
Tiree	56 30	6 53W	29	880	805	831	723	623	489	419	406	465	608	726	831	7806
Renfrew	55 52	4 26W	29	980	867	871	738	607	432	347	369	480	669	840	942	8142
Colmonell	55 8	4 57W	170	939	853	859	732	610	450	369	378	465	639	792	902	7988
Eskdalemuir	55 19	3 12W	794	1069	965	989	840	701	522	437	465	573	763	915	1029	9259
Douglas	54 10	4 28W	284	893	827	846	729	608	444	295	369	438	601	735	843	7628
Cockle Park	55 13	1 41W	325	1004	903	908	780	663	471	365	396	489	685	843	964	8471
Tynemouth	55 1	1 25W	108	933	838	852	735	644	447	338	353	429	608	765	889	7831
Durham	54 46	1 35W	336	1001	895	890	750	632	432	325	357	462	663	828	958	8193
York	53 57	1 5W	57	964	858	843	690	549	357	251	282	399	617	798	933	7541
Spurn Head	53 35	0 7E	29	949	855	862	714	595	399	276	282	363	564	750	902	7511
Gorleston	52 35	1 43E	5	933	847	859	705	577	381	263	257	339	549	741	905	7356
Felixstowe	51 57	1 20E	10	946	850	856	687	546	342	220	220	318	536	741	908	7170
Cambridge	52 12	0 8E	41	964	861	840	678	524	339	236	258	369	608	795	945	7417
Rothamsted	51 48	0 22W	420	998	895	874	714	564	378	273	295	402	635	825	973	7826
Sheffield	52 23	1 29W	428	955	869	853	702	561	369	267	291	402	614	786	918	7587
Nottingham	52 57	1 9W	192	958	861	840	661	536	345	249	273	384	611	792	930	7460
Birmingham (Sparkhill)	52 27	1 51W	425	970	869	852	684	536	342	251	279	393	623	801	946	7546
Oxford	51 46	1 16W	208	945	844	818	660	539	327	238	247	363	576	777	901	7235
Ross-on-Wye	51 55	2 35W	223	918	830	818	669	533	345	261	282	387	601	765	899	7308
Kew	51 28	0 19W	18	927	836	812	651	487	294	204	231	348	583	765	905	7043
Wisley	51 17	0 26W	150	942	844	818	660	502	321	220	241	360	591	806	897	7202
Dungeness	50 55	0 58E	20	915	836	846	690	555	372	267	248	327	524	714	884	7178
Southampton	50 55	1 24W	65	905	813	800	642	487	306	229	234	339	555	735	884	6929
Ventnor	50 36	1 13W	60	846	785	778	636	496	324	239	226	297	483	663	815	6588
Marlborough	51 25	1 44W	424	980	875	863	717	573	387	298	322	432	651	822	958	7883
Porton	51 7	1 42W	363	977	875	859	705	561	375	285	301	405	626	810	955	7734
Keswick	54 36	3 9W	254	942	858	856	729	586	411	325	347	456	642	792	908	7852
Manchester (Whitworth Park)	53 28	2 14W	125	930	841	821	675	527	345	264	289	393	605	777	908	7375
Southport	53 37	3 0W	35	942	847	840	693	561	384	288	307	405	608	777	905	7557
Stonyhurst	53 51	2 28W	377	986	892	883	735	583	408	322	344	451	651	819	945	8019
Bidston	53 24	3 4W	198	930	847	843	699	561	384	298	313	408	608	765	893	7549
Holyhead	53 19	4 37W	26	837	779	797	687	579	423	338	322	381	539	675	791	7148
Welshpool	52 39	3 8W	254	958	862	856	702	561	387	298	319	429	642	807	921	7742
St. Ann's Head	51 41	5 10W	142	812	771	796	687	579	420	341	319	378	524	654	769	7050
Cardiff	51 28	3 10W	203	911	827	812	666	527	343	267	276	375	580	747	880	7213
Portland Bill	50 32	2 27W	32	806	768	802	678	558	387	304	267	318	477	630	769	6764
Shaftesbury	51 1	2 12W	680	964	875	859	708	573	387	303	310	408	617	795	939	7738
Gullompton	50 51	3 23W	202	902	813	797	648	502	318	242	267	372	583	756	887	7087
Plymouth	50 21	4 7W	87	818	759	756	627	502	330	266	267	336	512	675	800	6648
Scilly	49 56	6 18W	163	735	686	710	630	536	378	295	273	330	477	600	707	6357
Armagh	54 21	6 39W	205	924	824	828	711	564	408	338	357	456	639	789	896	7734

TABLE IV. Averages of Accumulated Temperature below 60°F. (in degree-days)
at 49 stations, period 1921-50

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Lerwick	676	624	651	555	446	315	204	205	282	437	540	626	5561
Wick	654	590	601	510	415	270	170	176	237	384	510	605	5122
Fortrose	660	584	564	438	313	171	84	102	192	366	528	626	4628
Stornoway	605	551	558	474	366	228	140	141	225	369	486	564	4707
Aberdeen	660	587	586	480	369	192	90	119	204	370	522	617	4796
Braemar	809	717	704	570	425	243	149	189	300	493	660	760	6019
Leuchars	679	596	570	450	338	165	74	96	186	360	534	639	4687
Edinburgh	663	598	580	465	338	165	74	102	183	360	516	617	4661
Tiree	570	522	521	423	313	189	112	102	168	298	426	521	4165
Renfrew	670	584	561	438	298	153	74	95	189	359	540	632	4593
Colmonell	629	570	549	432	301	156	87	87	171	329	492	592	4395
Eskdalemuir	759	683	670	540	391	225	143	167	273	453	615	719	5638
Douglas	583	545	536	429	298	156	92	93	146	291	435	533	4137
Cockle Park	694	621	598	480	353	177	89	116	195	375	543	654	4895
Tynemouth	623	556	542	435	335	151	62	77	141	298	465	579	4264
Durham	691	613	580	450	322	148	68	89	172	353	528	648	4662
York	654	576	533	390	242	96	40	54	122	307	498	623	4135
Spurn Head	639	573	552	414	285	116	26	36	99	254	450	592	4036
Gorleston	623	565	549	405	267	155	20	36	79	239	441	595	3974
Felixstowe	635	567	546	387	235	81	16	22	81	233	441	598	3842
Cambridge	654	579	530	378	217	78	36	46	111	298	495	635	4057
Rothamsted	688	613	564	414	258	100	49	64	137	325	525	663	4400
Sheffield	645	587	543	402	255	107	51	57	125	304	486	608	4170
Nottingham	648	579	530	381	230	88	45	54	115	301	492	620	4083
Birmingham (Sparkhill)	660	587	542	384	229	84	47	56	120	313	501	636	4159
Oxford	635	562	508	360	208	71	36	44	106	285	477	611	3903
Ross-on-Wye	608	548	508	369	226	79	49	51	112	291	465	589	3895
Kew	617	553	502	351	187	56	27	39	103	273	465	595	3768
Wisley	632	562	508	360	198	66	37	47	109	282	480	616	3897
Dungeness	605	553	536	390	245	85	29	24	82	230	414	574	3767
Southampton	595	531	490	342	182	59	37	38	90	249	435	574	3622
Ventnor	536	502	468	336	188	63	34	31	66	183	363	505	3275
Marlborough	670	593	558	417	263	105	62	68	153	341	522	648	4400
Porton	667	592	549	405	251	99	56	65	135	316	510	645	4290
Keswick	632	576	546	429	275	143	65	81	168	332	492	598	4337
Manchester (Whitworth Park)	620	559	511	375	220	90	52	66	125	295	477	598	3988
Southport	632	565	530	393	251	103	46	56	118	298	477	595	4064
Stonyhurst	676	610	573	435	273	131	68	83	154	341	519	635	4498
Bidston	620	565	533	399	251	103	60	65	123	298	465	583	4065
Holyhead	527	497	487	387	269	126	65	59	100	229	375	481	3602
Welshpool	648	579	528	402	251	117	65	74	144	332	507	611	4258
St. Ann's Head	502	488	486	387	270	129	77	58	97	242	354	458	3548
Cardiff	601	545	502	366	217	87	49	53	108	270	449	570	3817
Portland Bill	496	486	492	378	248	102	49	37	60	180	339	459	3326
Shaftesbury	654	592	549	408	263	114	71	65	138	307	495	629	4285
Cullompton	592	531	487	348	194	69	37	46	103	273	456	576	3712
Plymouth	508	477	446	327	194	75	49	43	87	208	375	490	3279
Scilly	425	404	400	330	226	96	53	45	75	171	300	397	2922
Armagh	614	542	518	411	254	126	72	84	165	329	489	586	4190

TABLE V. Averages of Accumulated Temperature below 50°F. (in degree-days)
at 49 stations, period 1921-50

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Lerwick	366	342	346	255	141	68	13	19	43	144	240	316	2293
Wick	344	308	301	213	115	30	0	6	18	99	213	295	1942
Fortrose	353	305	270	153	62	12	0	0	0	90	234	319	1798
Stornoway	298	268	256	180	82	26	0	3	27	93	192	263	1688
Aberdeen	350	309	292	192	87	15	0	0	3	90	229	311	1878
Braemar	499	435	431	273	130	42	6	21	63	192	360	456	2908
Leuchars	375	319	276	168	65	12	0	0	12	87	237	332	1883
Edinburgh	366	322	285	180	80	15	0	0	15	93	219	313	1888
Tiree	264	246	223	130	28	6	0	0	3	37	132	217	1286
Renfrew	378	308	267	156	50	12	0	0	18	96	243	332	1760
Colmonell	338	296	251	144	37	3	0	0	3	69	198	291	1630
Eskdalemuir	449	401	366	243	99	27	3	9	51	155	315	409	2527
Douglas	282	265	233	141	31	3	0	0	3	37	147	232	1375
Cockle Park	389	343	304	192	74	18	0	3	21	93	243	347	2027
Tynemouth	317	283	252	158	71	0	0	0	2	50	258	310	1701
Durham	387	335	285	174	65	7	0	0	17	84	231	343	1928
York	363	304	243	124	31	0	0	0	2	63	209	318	1651
Spurn Head	333	301	256	133	42	0	0	0	0	37	158	287	1288
Gorleston	324	292	253	129	31	0	0	0	0	29	154	295	1288
Felixstowe	335	302	248	117	25	0	0	0	0	34	159	298	1288
Cambridge	363	314	233	116	25	0	0	0	0	60	206	336	1283
Rothamsted	391	342	284	140	39	0	0	0	10	71	232	359	1868
Sheffield	347	322	254	137	41	4	0	0	3	63	193	307	1671
Nottingham	350	333	239	120	28	0	0	0	5	56	203	320	1654
Birmingham (Sparkhill)	369	322	245	123	31	0	0	0	3	53	213	335	1694
Oxford	343	304	214	105	21	0	0	0	4	52	198	310	1551
Ross-on-Wye	324	289	215	111	22	0	0	0	2	57	186	295	1501
Kew	325	288	209	100	18	0	0	0	3	45	180	295	1463
Wisley	341	302	214	105	19	0	0	0	2	56	201	316	1556
Dungeness	319	285	233	117	26	0	0	0	0	25	144	279	1428
Southampton	310	271	195	93	6	0	0	0	0	43	154	279	1351
Ventnor	254	246	178	75	6	0	0	0	0	19	108	220	1106
Marlborough	372	321	257	141	33	0	0	0	12	81	234	347	1798
Porton	369	327	248	108	29	0	0	0	9	68	222	341	1721
Keswick	341	302	248	150	43	6	0	0	21	80	219	310	1720
Manchester (Whitworth Park)	328	292	225	109	22	0	0	0	5	60	192	298	1531
Southport	341	292	232	119	23	0	0	0	0	57	192	295	1551
Stonyhurst	371	332	272	157	42	3	0	0	9	18	226	330	1760
Bidston	328	292	236	128	27	0	0	0	3	56	175	282	1527
Holyhead	235	225	186	105	19	0	0	0	0	19	99	178	1066
Weshpool	357	314	248	126	28	6	0	0	6	84	219	310	1698
St. Ann's Head	213	225	183	102	21	0	0	0	0	15	86	173	1018
Cardiff	307	284	313	69	20	0	0	0	3	49	165	275	1485
Portland Bill	217	228	189	102	19	0	0	0	0	12	117	183	1067
Shaftesbury	356	327	248	129	41	3	0	0	9	65	207	319	1704
Cullompton	307	271	192	96	9	0	0	0	0	43	180	282	1380
Plymouth	229	220	155	75	9	0	0	0	0	18	111	208	1025
Scilly	140	141	105	60	9	0	0	0	0	6	54	118	633
Armagh	313	268	226	114	28	4	0	0	6	87	198	285	1529

TABLE VI. Averages of Accumulated Temperature below 42°F. (in degree-days)
at 49 stations, period 1921-50

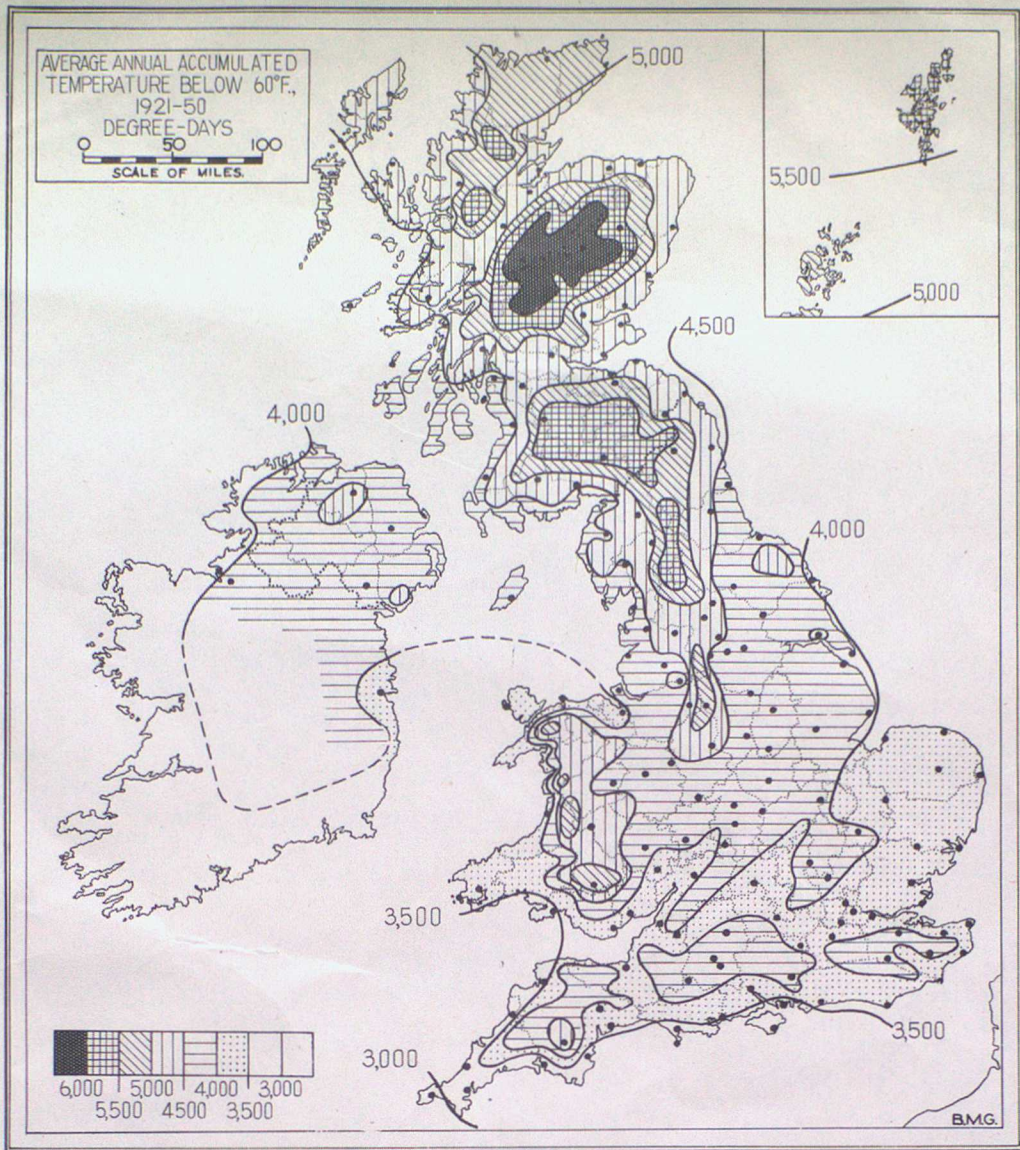
Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Lerwick	144	136	144	57	7	0	0	0	0	20	56	116	680
Wick	127	116	124	105	3	0	0	0	0	0	48	99	622
Fortrose	174	121	105	24	0	0	0	0	0	4	57	124	609
Stornoway	99	85	79	33	27	0	0	0	0	3	36	85	447
Aberdeen	146	126	119	45	0	0	0	0	0	3	58	113	610
Braemar	189	236	152	87	12	0	0	0	0	40	141	236	1093
Leuchars	164	138	109	39	0	0	0	0	0	0	60	130	640
Edinburgh	164	141	111	36	0	0	0	0	0	0	51	121	624
Tiree	81	79	62	6	0	0	0	0	0	0	6	49	283
Renfrew	177	133	99	24	0	0	0	0	0	9	60	142	644
Colmonell	155	121	78	18	0	0	0	0	0	0	39	105	516
Eskdalemuir	236	203	161	69	3	0	0	0	0	22	108	195	997
Douglas	102	93	65	12	0	0	0	0	0	0	18	65	355
Cockle Park	176	155	124	45	0	0	0	0	0	0	60	139	699
Tynemouth	124	115	90	30	0	0	0	0	0	0	30	72	461
Durham	183	161	110	40	0	0	0	0	0	3	60	141	698
Fork	177	136	85	20	0	0	0	0	0	0	52	196	666
Spurn Head	130	129	87	18	0	0	0	0	0	0	19	94	477
Corleston	140	124	84	17	0	0	0	0	0	0	23	112	500
Felixstowe	149	138	81	18	0	0	0	0	0	0	30	112	528
Cambridge	179	152	75	16	0	0	0	0	0	0	52	147	621
Rothamsted	192	169	121	25	8	0	0	0	0	0	64	162	741
Sheffield	163	151	96	23	0	0	0	0	0	0	42	122	597
Nottingham	168	143	79	18	0	0	0	0	0	0	54	135	597
Birmingham (Sparkhill)	179	155	78	18	0	0	0	0	0	0	54	143	627
Oxford	170	146	63	13	0	0	0	0	0	0	52	133	577
Ross-on-Wye	155	136	58	14	0	0	0	0	0	0	48	122	533
Kew	149	133	56	11	0	0	0	0	0	0	42	152	543
Wisley	164	141	58	12	0	0	0	0	0	0	55	130	560
Dungeness	146	127	62	15	0	0	0	0	0	0	27	112	489
Southampton	140	117	47	9	0	0	0	0	0	0	28	109	450
Ventnor	100	97	31	3	0	0	0	0	0	0	12	37	280
Marlborough	189	158	77	24	0	0	0	0	0	3	75	151	677
Porton	183	161	71	24	0	0	0	0	0	0	69	146	654
Keswick	161	130	84	23	0	0	0	0	0	4	54	127	583
Manchester (Whitworth Park)	153	130	70	11	0	0	0	0	0	0	47	120	531
Southport	159	126	63	13	0	0	0	0	0	0	39	117	517
Stonyhurst	140	150	89	28	0	0	0	0	0	3	62	137	609
Bidston	144	126	74	17	0	0	0	0	0	0	34	107	502
Holyhead	78	79	34	3	0	0	0	0	0	0	3	47	244
Welshpool	177	150	81	18	0	0	0	0	0	3	66	130	625
St. Ann's Head	68	82	31	2	0	0	0	0	0	0	0	43	226
Cardiff	133	127	49	15	0	0	0	0	0	0	36	102	462
Portland Bill	73	87	31	3	0	0	0	0	0	0	24	50	260
Shaftesbury	164	158	65	147	0	0	0	0	0	3	48	136	721
Cullompton	136	113	37	120	0	0	0	0	0	0	42	105	553
Plymouth	28	82	22	3	0	0	0	0	0	0	13	68	216
Scilly	22	25	3	0	0	0	0	0	0	0	0	16	66
Armagh	130	101	68	27	0	0	0	0	0	0	45	105	476

TABLE VII. Averages of Accumulated Temperature above 42°F. (in degree-days)
at 49 stations, period 1921-50

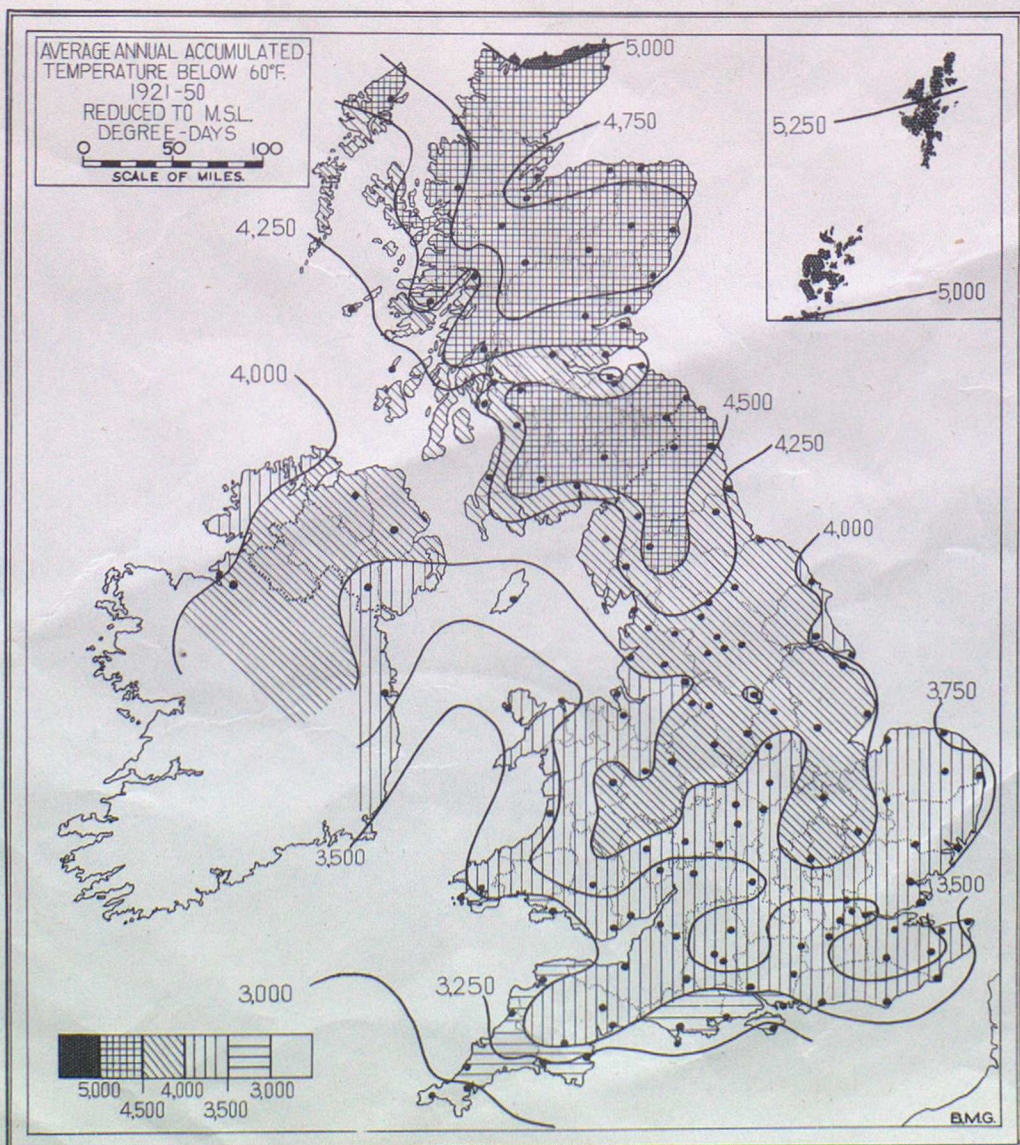
Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Lerwick	26	25	51	43	118	228	357	357	258	141	56	47	1706
Wick	31	36	76	75	147	270	391	387	303	179	77	53	2025
Fortrose	73	45	97	125	245	381	505	484	354	198	62	58	2627
Stornoway	53	48	76	96	123	312	425	425	318	195	90	55	2216
Aberdeen	46	48	90	103	192	351	484	456	336	192	74	53	2425
Braemar	33	28	64	57	145	300	422	378	243	103	21	39	1833
Leuchars	43	52	95	124	220	384	511	484	360	205	66	54	2598
Edinburgh	60	49	95	111	220	387	511	484	363	205	74	67	2626
Tiree	68	69	100	124	245	351	449	462	375	260	121	85	2709
Renfrew	70	59	92	126	260	408	521	499	360	209	63	65	2732
Colmonell	85	64	87	126	257	390	499	490	375	229	89	81	2772
Eskdalemuir	31	25	47	69	171	318	431	403	267	124	33	34	1953
Douglas	78	60	86	125	260	396	496	499	402	267	122	92	2883
Cockle Park	43	45	87	102	205	369	502	471	351	189	57	47	2468
Tynemouth	60	65	105	135	226	393	530	515	411	260	103	70	2873
Durham	54	54	92	129	239	408	543	511	378	208	74	50	2740
York	77	73	109	168	319	483	617	582	441	254	93	65	3281
Spurn Head	54	69	95	143	273	441	592	586	477	304	109	61	3204
Gorleston	74	68	93	152	291	459	605	611	501	319	121	74	3368
Felixstowe	72	79	93	161	384	498	648	648	522	332	128	71	3636
Cambridge	84	82	105	180	344	501	636	614	471	261	93	68	3439
Rothamsted	68	71	115	152	304	462	595	573	438	236	76	55	3145
Sheffield	77	71	112	162	307	471	605	577	438	258	94	71	3243
Nottingham	79	80	107	179	332	495	626	598	456	257	97	73	3379
Birmingham (Sparkhill)	83	79	96	175	332	498	623	592	447	248	96	68	3337
Oxford	93	96	112	195	356	513	645	623	477	273	117	81	3581
Ross-on-Wye	108	99	108	186	335	495	611	586	453	267	120	92	3460
Kew	93	87	109	201	381	546	676	644	492	285	117	78	3709
Wisley	90	87	108	195	366	519	648	626	480	276	115	73	3583
Dungeness	97	77	83	163	313	468	601	620	513	344	154	97	3530
Southampton	102	99	115	210	381	534	644	642	501	313	135	93	3769
Ventnor	116	103	122	207	372	516	632	648	543	384	188	120	3951
Marlborough	73	71	79	145	295	453	570	546	408	223	91	66	3020
Porton	72	73	78	158	307	465	583	567	435	245	99	58	3140
Keswick	87	62	96	135	282	429	543	521	384	230	97	83	2949
Manchester (Whitworth Park)	89	80	116	179	341	495	608	583	447	263	108	79	3388
Southport	84	68	90	159	307	456	579	561	435	267	108	77	3191
Stonyhurst	53	52	79	134	285	432	546	524	387	220	82	67	2861
Bidston	85	67	98	159	307	456	570	555	432	260	108	82	3179
Holyhead	105	89	104	161	288	417	530	546	459	329	171	121	3320
Welshpool	87	79	93	153	307	453	570	549	411	233	99	77	3111
St. Ann's Head	123	99	102	158	288	420	527	549	462	344	192	142	3406
Cardiff	94	87	105	189	341	495	601	592	465	288	127	87	3471
Portland Bill	135	110	96	167	310	453	564	601	522	391	235	146	3730
Shaftesbury	69	75	84	149	295	453	567	558	432	255	95	64	3096
Cullompton	105	96	111	203	366	522	629	605	468	285	137	95	3622
Plymouth	127	115	136	216	366	510	605	608	504	357	179	133	3856
Scilly	156	128	163	210	332	462	573	595	510	391	240	175	3935
Armagh	68	68	109	159	285	432	530	511	384	229	93	74	2942

TABLE VIII. Averages of Accumulated Temperature above 60°F. (in degree-days)
at 49 stations, period 1921-50

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Lerwick							3	3					3
Wick							3	3					6
Fortrose						9	31	31	3				74
Stornoway							6	6					12
Aberdeen						3	19	15					37
Braemar							12	6					18
Leuchars						9	25	25	3				62
Edinburgh						12	31	31	3				77
Tiree							3	3					6
Renfrew						21	37	40	6				104
Colmonell						3	31	19	3				56
Eskdalemuir							15	9					24
Douglas						9	31	34	6				80
Cockle Park						3	28	28	6				65
Tynemouth						3	34	37	12				86
Durham						15	53	43	9				120
York						39	96	81	24				240
Spurn Head						15	59	65	36				175
Gorleston						15	68	84	45				212
Felixstowe						40	105	112	66	3			326
Cambridge					3	42	112	102	45				304
Rothamsted						21	87	47	36				191
Sheffield						39	93	77	25				234
Nottingham					3	45	109	93	33				283
Birmingham (Sparkhill)					3	42	112	90	30				277
Oxford					3	45	124	105	42				319
Ross-on-Wye						36	102	81	24				243
Kew					6	63	146	124	54				393
Wisley					3	45	121	115	51				335
Dungeness						15	71	87	57	3			233
Southampton					3	54	121	121	51	6			356
Ventnor						39	109	121	69	9			347
Marlborough						18	71	59	21				169
Porton						27	84	74	30				215
Keswick						27	50	43	9				129
Manchester (Whitworth Park)						48	99	93	33				273
Southport						21	68	59	15				163
Stonyhurst						24	59	50	9				142
Bidston						21	68	62	15				166
Holyhead						3	37	50	18				108
Welshpool						27	71	68	15				181
St. Ann's Head						9	47	50	21				127
Cardiff						45	93	90	33				261
Portland Bill						15	56	77	42	6	3.		199
Shaftesbury						24	84	65	33				206
Cullompton						51	105	93	30				279
Plymouth						45	93	96	51	3			288
Scilly						18	68	84	75	3			248
Armagh						18	43	37	6				104



P.R.B.S- 330



P.R.B.S- 330

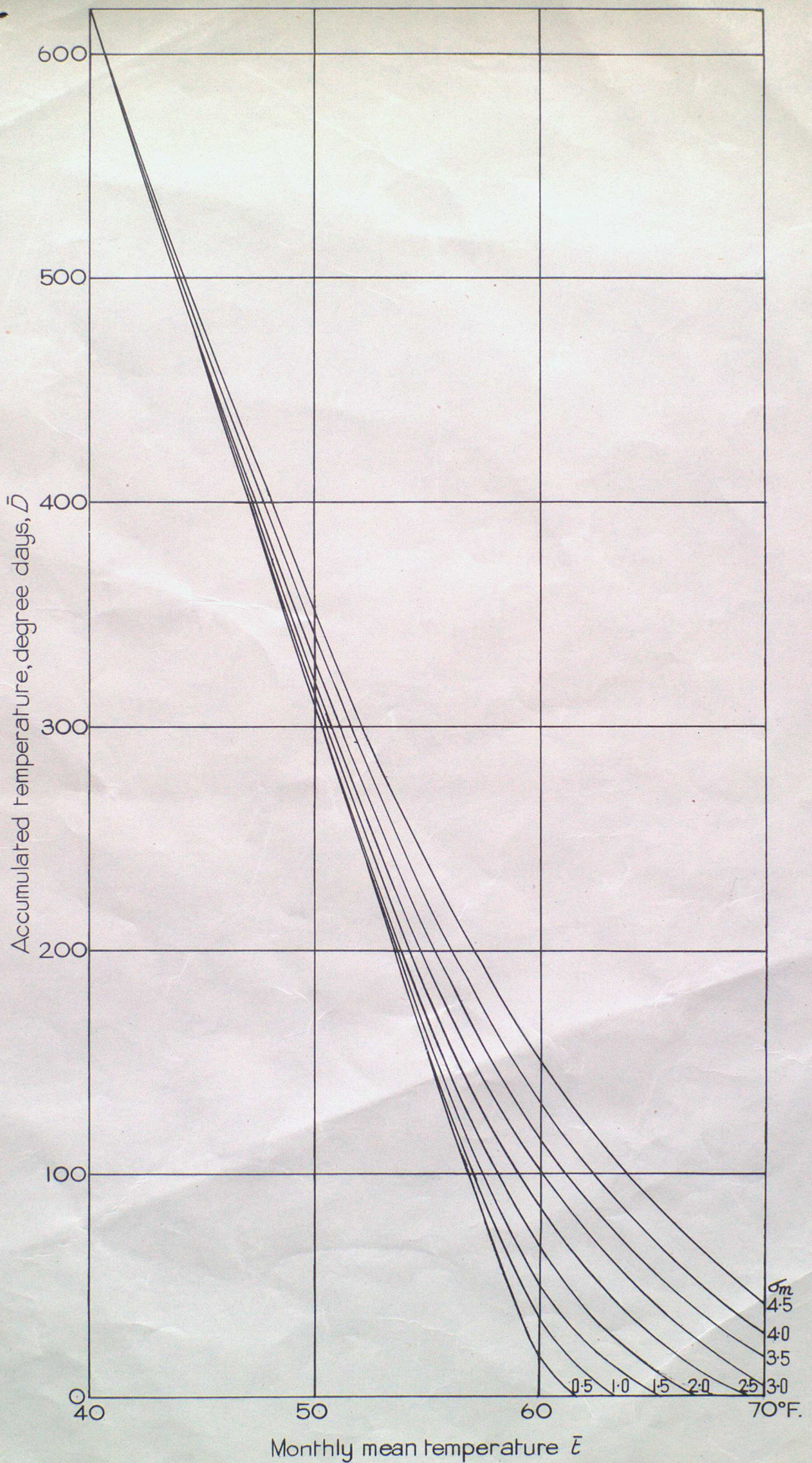


Fig.3 Relation between accumulated temperature below 60°F. and monthly mean temperature for various values of σ_m and $N=31$

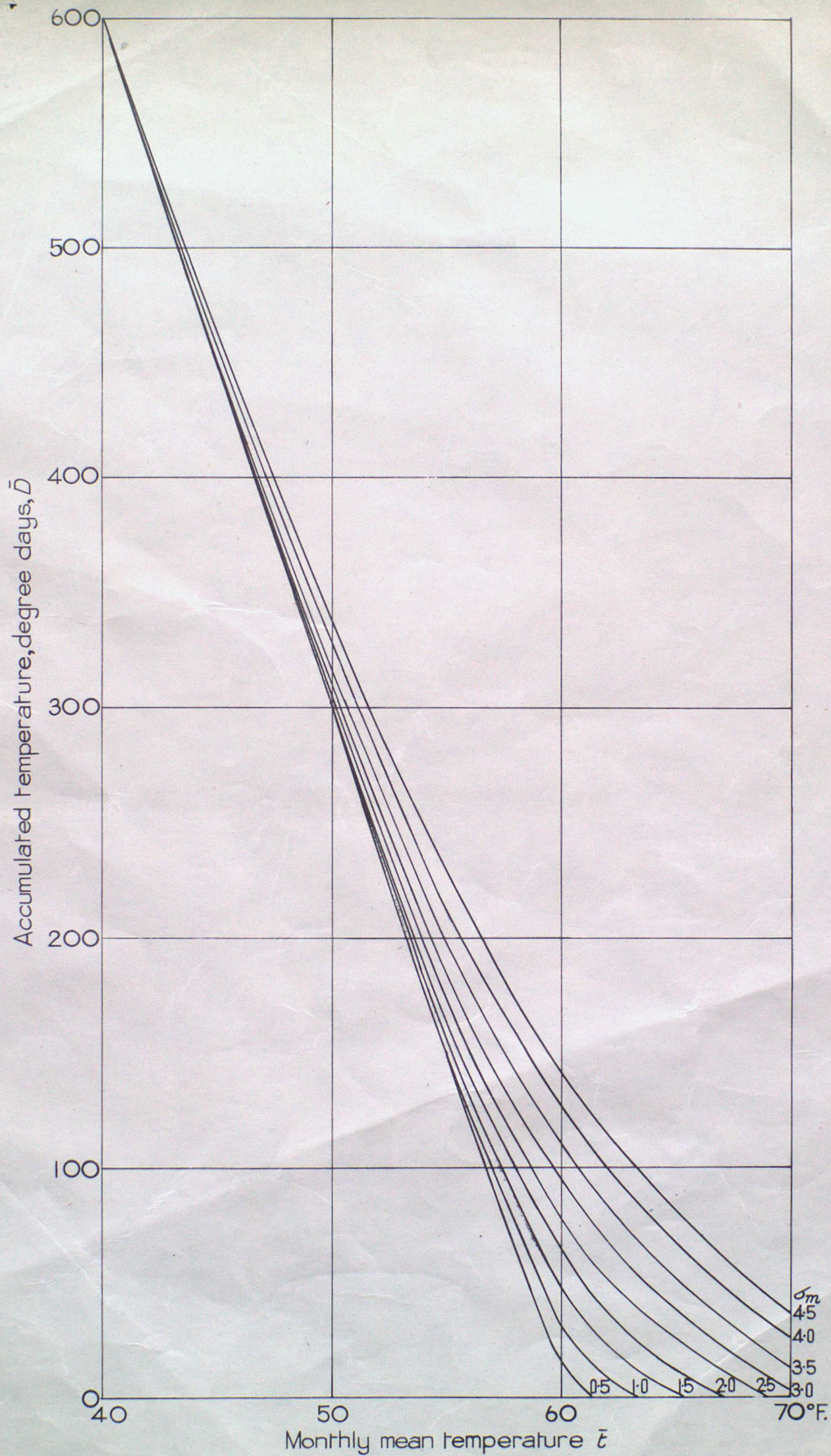


Fig.4 Relation between accumulated temperature below 60°F and monthly mean temperature for various values of σ_m and $N=30$