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CHARACTERISTICS OF AIR MASSES OVER THE BRITISH ISLES

BY

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CHARACTERISTICS OF AIR MASSES OVER THE BRITISH ISLES

PART I—INTRODUCTORY

§ 1—GENERAL AND SUMMARY

In 1945 a contribution was made to the climatology of the British Isles in winter by a classification of average temperature at the surface and in the upper air in terms of the source and life history of the air[1*]. The material has been re-worked and extended to include the summer and the individual months of the year. The complete work has formed the subject of a thesis[2] which is available for reference at the University of London Library, Senate House, W.C.1. This Memoir is an abridgement, with some modifications and additions, of this thesis.

Goldie[3], Schinze[4], Palmén[5], Willet[6], Petterssen[7] and others have obtained mean or single values of temperature in the main classes of air in different parts of the world. In this Memoir advantage has been taken of recent extensive upper air data to investigate the characteristics of the more important physical properties of the atmosphere over the British Isles in subdivisions of tropical and polar air and of indeterminate air in the central region of quasi-stationary anticyclones.

The discussion of the observations is divided into two parts. The first part is concerned with the effect, in the upper air between 950 mb. and 450 mb. in summer and winter, of different air masses on (*a*) the vertical distribution of temperature and water vapour and (*b*) the degree of thermal stability of the atmosphere. It includes a discussion of the average changes of temperature, humidity and thermal stability which take place at corresponding pressures in tropical maritime and direct polar air during the journeys of these air masses to the British Isles. The effect of radiation is considered where possible.

The second part of the discussion examines the influence of the different air masses upon surface temperature and humidity at Kew, and the incidence, at the surface, of different air masses at 1800 G.M.T. at Kew, Scilly and Stornoway.

For each air mass tables of upper air averages are given in Appendices I and II, of surface averages at Kew in Appendices III, IV and V, and of the monthly percentage frequencies at 1800 G.M.T. at the surface at Kew, Scilly and Stornoway in Appendix VI.

§ 2—CLASSIFICATION OF THE AIR MASSES

In the 1945 paper the classification of types of air mass was into 12 groups only. Here the upper air data over the British Isles are divided into 14 classes; of these, 3 are tropical, 1 quasi-tropical, 9 polar and 1 indeterminate (anticyclonic air). Over the Azores region there is 1 tropical class and over the Icelandic region 1 polar class. The data used were published in the *Upper Air Section of the Daily Weather Report* (Meteorological Office, London). At the surface in the British Isles there are 19 types of air mass, four of the additional classes being

* These numbers refer to the Bibliography on p. 25.

indeterminate anticyclonic types in which the recent course of the air might be expected to have a definite effect on the surface air though probably little influence on the air at higher levels. These classes are thus those parts of the tropical and polar classes with anticyclonic tracks which border upon the central region of the adjacent anticyclone.

The classification of the air masses is summarized in Table I, and Figs. 1–3 show the generalized tracks of air from the different sources.

Classes of air outside the British Isles (tropical air, T_A, in the Azores region and direct polar air, P_{IC}, in the Icelandic region) have been included so that estimates can be made of the modifications which occur to the properties of these air masses during their journey to the British Isles.

TABLE I—GENERAL CLASSIFICATION OF THE AIR MASSES

Air mass	Sub-division symbol	Source region	Main curvature of path to British Isles	Nature of path surface	Direction of approach to British Isles	Number of observations of: Upper air temperature (900 mb.) Summer	Upper air temperature (900 mb.) Winter	Surface temperature at Kew‡ Maximum Summer	Maximum Winter	Minimum Summer	Minimum Winter
	T_A*	South-west of Azores	Anticyclonic	..	..	22	20	..	..	..	..
Tropical, maritime	T_1	South-west of Azores	Straight	Oceanic	SW.	25	31	40	51	34	40
Tropical, maritime	T_2	South-west of Azores	Anticyclonic	Oceanic	S. or SW.	18	18	21	37	21	35
Tropical, continental	T_3	Spain, Mediterranean or north-west Africa; southern Europe in summer	Straight	Land and English Channel	SE. or S.	27	12	15	11	16	9
Tropical, continental	T_4†	Spain, Mediterranean or north-west Africa; southern Europe in summer	Anticyclonic	Land and English Channel	E. or SE.	..	..	21	15	20	13
Quasi-tropical maritime	T_Q	43–50° N., 15–25° W.	Straight or anticyclonic	Oceanic	SW., W. or NW.	30	38	28	32	27	33
Indeterminate anticyclonic air in and near the central region of an anticyclone	H_0	..	Anti-cyclonic	Mainly land	Indefinite	24	11	24	21	25	22
	N_{NE}†	..	Anti-cyclonic	Land and North Sea	NE.–E.	..	..	42	16	44	18
	H_{SE}†	..	Anti-cyclonic	Land and eastern English Channel	SE.–S.	..	..	46	39	43	37
	H_{SW}†	..	Anti-cyclonic	Land and western English Channel	SW.–W.	..	..	31	19	28	16
	H_{NW}†	..	Anti-cyclonic	British Isles and oceanic	NW.–N.	..	..	22	29	23	30
Polar, continental	A_1	North of 50° N. and east of 25° E.	Cyclonic	Land and North Sea	NE., E. or SE.	..	24	..	40	..	36
Polar, continental	A_2	North of 50° N. and east of 25° E.	Anticyclonic	Land and North Sea	NE., E. or SE.	..	20	..	24	..	27
Polar	P_{IC}*	North and north-east of Iceland	Cyclonic	..	..	21	20	..	..	..	..
Polar, maritime	P_1	North and north-east of Iceland	Cyclonic	Oceanic	N. or NE.	35	28	39	40	37	42
Polar, maritime	P_2	North and north-east of Iceland	Anticyclonic	Oceanic	N. or NE.	18	22	27	24	28	26
Polar, maritime	P_3	North-west and west of Iceland	Cyclonic	Oceanic	NW.	56	33	62	36	60	35
Polar, maritime	P_4	North-west and west of Iceland	Anticyclonic	Oceanic	NW.	32	21	56	60	54	62
Polar, maritime	P_5	North-west and west of Iceland	Cyclonic	Oceanic	W.	51	33	62	47	63	46
Polar, maritime	P_6	North-west and west of Iceland	Anticyclonic	Oceanic	W.	38	21	63	51	61	52
Polar, maritime	P_7	North-west and west of Iceland	Cyclonic	Oceanic	S. or SW.	14	24	15	24	15	25

* These classes of air mass, at their source region, are included for comparison with corresponding air masses reaching the British Isles.
† Surface classes only.
‡ Observations were only used if the relevant air mass passed over Kew for a substantial period including the normal time of maximum or minimum temperature.

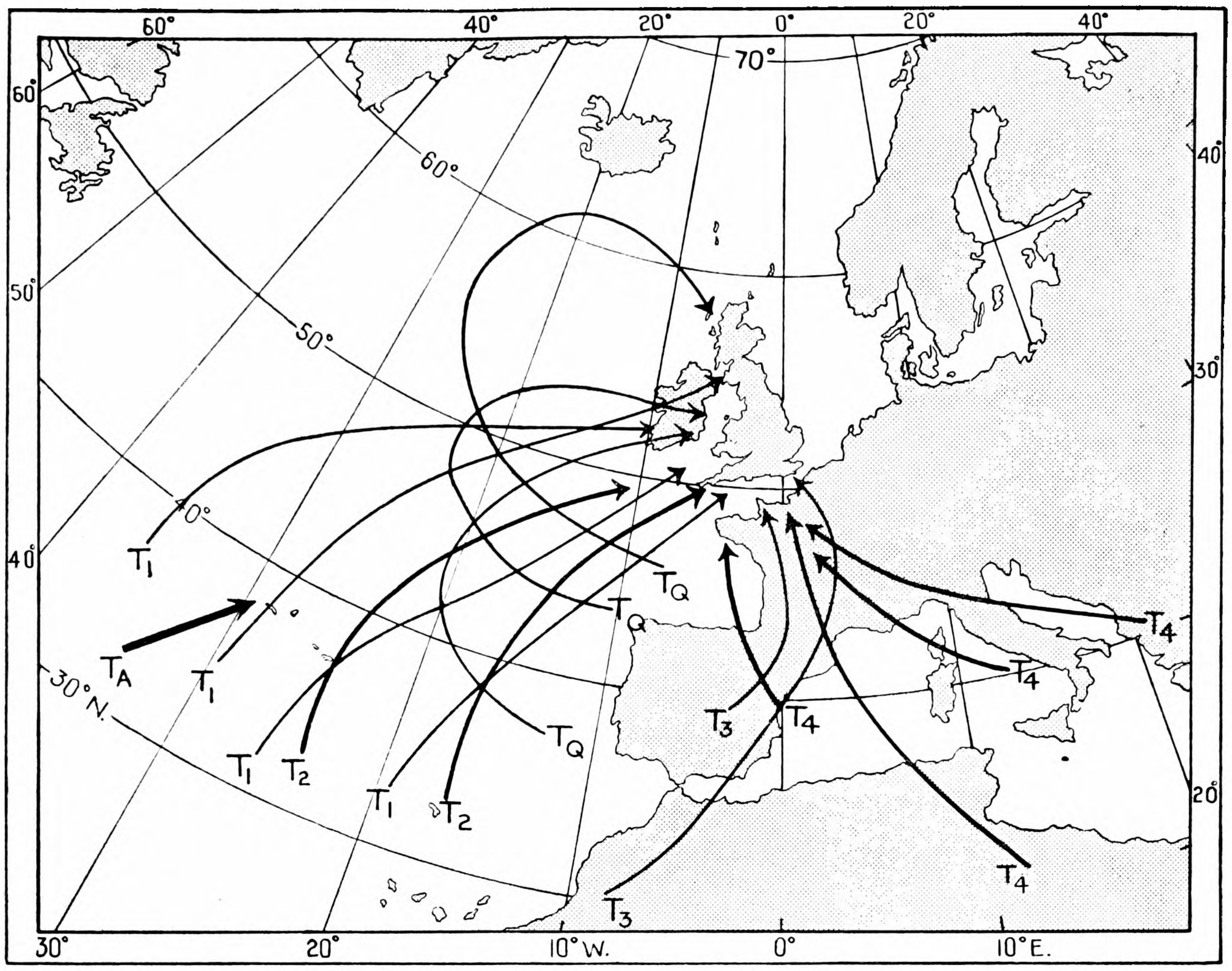

FIG. 1—GENERALIZED TRACKS OF THE TROPICAL AND QUASI-TROPICAL AIR MASSES

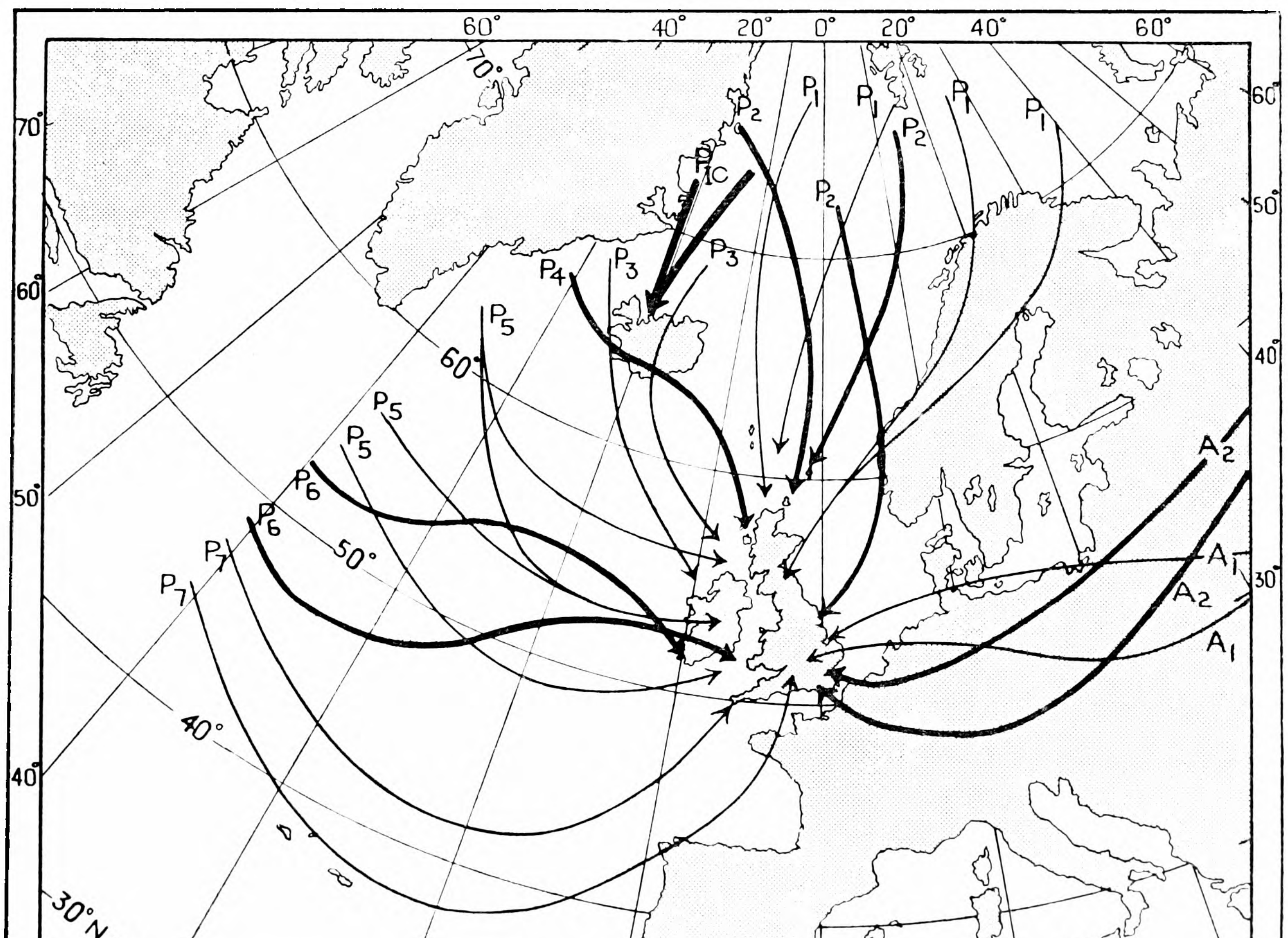

FIG. 2—GENERALIZED TRACKS OF THE POLAR AIR MASSES

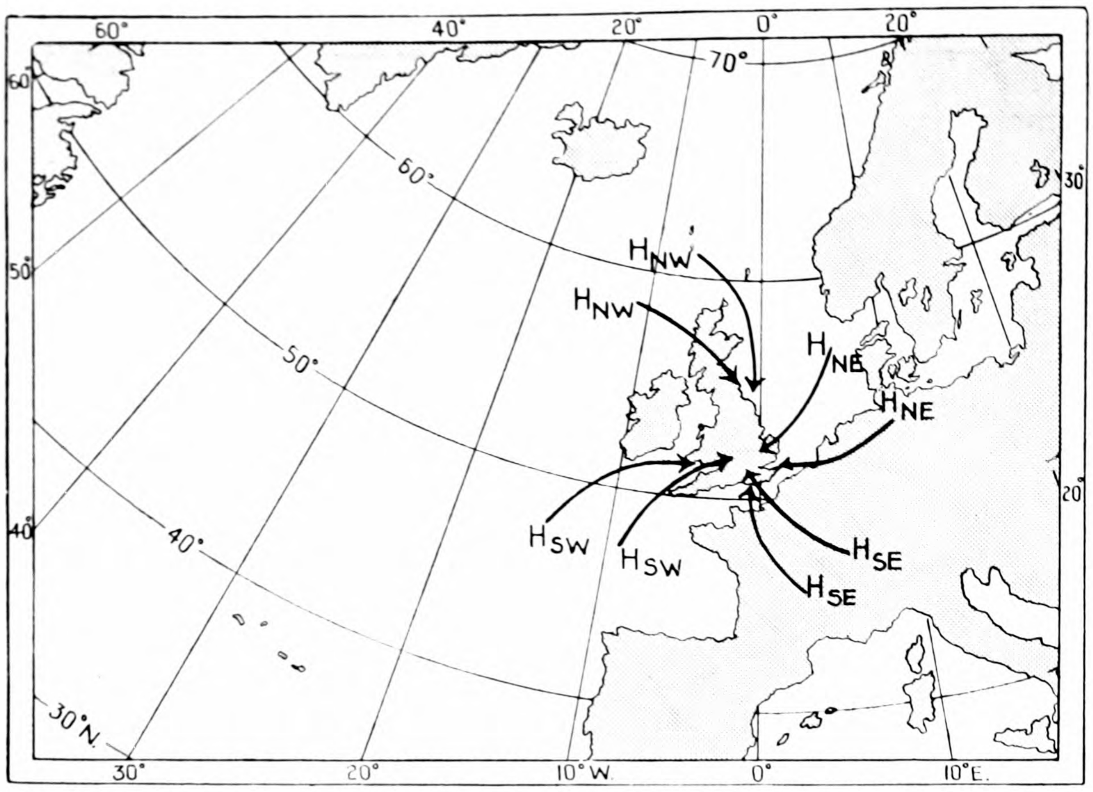

FIG. 3—GENERALIZED TRACKS OF THE ANTICYCLONIC (INDETERMINATE) AIR MASSES

The method adopted in tracing the trajectory of an air mass, arriving over the station whose observations were used, was as follows: an estimate was made of the geostrophic wind, at the station, from the synoptic charts of surface isobars published in the *International Section of the Daily Weather Report*, and the position of the air mass on the next previous synoptic chart determined. Because of the uncertainty involved in this method, in particular in determining the trajectories of the air at increasing heights above the geostrophic level, it was not considered advisable to trace back the air for more than 36 hours at the most. In general the air was not traced back for more than 24 hours. If, during the interval between the synoptic charts (about 6 hours), the trajectory was found to cross a front, judgement was used to relate the position of the air to the front so that the front was not crossed. In some cases where the air was slow-moving there is some uncertainty that the air mass, which eventually reached the British Isles, originated at the source deduced from the trajectory. It is believed, however, that the precautions taken have obviated any serious effects which these uncertainties might have had on the results. Advantage was taken of the analysis of the synoptic charts to determine the main class to which an air mass belonged.

In the 1945 paper examples are given of the synoptic situations associated with most of the winter types. Examples of the synoptic situations associated with the remainder are included in the complete work[2]. They are not reproduced here.

§ 3—TREATMENT OF THE DATA

The basis of the examination has been the elements of temperature and humidity. At the surface these were recorded in the north-wall screen at Kew. In the upper air they were recorded by aeroplane and radio-sonde at fixed pressure levels at intervals of 50 mb. from 950 mb. to 450 mb. To avoid the different effects on temperature at the surface due to solar radiation and nocturnal cooling values below 950 mb. were not used, while those at 950 mb. were confined to soundings made in the early morning.*

* In the 1945 paper, the heights treated were the geometrical ones of 1,000, 2,000, 3,000, 5,000, 10,000, 15,000 and 20,000 ft.; the winter season was taken to be December, January, and February; and the period chosen for the analysis of the upper air data was the 14 winters, 1930–31 to 1943–44 and of the surface data the 20 winters 1924–25 to 1943–44.

Summer has been represented by July and August, winter by January and February. The choice of these months was adopted because, on examination, it was found that the changes of mean monthly temperature are least between January and February and between July and August (see Appendix I).

The investigation into temperature and humidity covers the 15 years, 1931–45, over the British Isles, and the 3 years 1943–45 over Iceland and the Azores. The incidence at 1800 G.M.T. of the different classes of air at the surface covers the 12 years 1938–49. Only observations taken well inside the different air masses have been used.

In the upper air, simultaneous observations of temperature and humidity were extracted for the summer and winter seasons, and temperature for the individual months. Only one sounding a day in any one class of air was used so as to avoid the danger of undue weighting in favour of certain air masses. When above some level there was a different type of air mass (as indicated by a deep layer of diminished lapse rate) only those temperatures from 950 mb. to the base of this layer were used. Even so, some uncertainty remained that the same air mass existed in the upper layers as in the lower layers because of the shear of wind.

At the surface, maximum and minimum temperatures for the 24 hours, midnight to midnight, and the mean vapour pressure for this period were extracted on those days when no important change of air mass occurred. Maximum or minimum temperatures were also used on those days when there was a change of air mass if this change did not take place at the normal time of occurrence of these temperatures.

Days when the air mass could not be readily assigned to one or other of the different categories were excluded. In the lower layers of the upper air there were 562 of these days in summer and 543 in winter. At the surface maximum and minimum temperatures could not be used respectively on 316 and 331 days in summer and on 261 and 275 days in winter.

In order to obtain the characteristics of an air mass, the mean values of its meteorological elements, derived from a number of soundings taken in the air mass, have been used. The numbers of ascents used for each air mass at 900 mb. is given in Table I.

At any pressure, p, in an air mass the mean temperature $\bar{T}$ and mean height $\bar{h}$ are the arithmetic means of individual values at this pressure level. The mean partial thicknesses at 700 mb. and 500 mb. are the arithmetic means of individual values derived from the heights of the 1000 mb., 700 mb. and 500 mb. pressure levels.

The mean absolute humidity $\bar{d}$ is the arithmetic mean of individual values each obtained, from published individual values of temperature and corresponding relative humidity, by means of tables[8]. In the upper air relative humidity below 32°F. cannot always be regarded as reliable owing to the difficulty of ensuring the correct functioning of the ice-covered wet bulb.

The mean vapour pressure, $\bar{e}$, was derived from the equation

$$\bar{e} = \frac{\bar{T}\,\bar{d}}{216 \cdot 7},$$

using the relationship

$$\overline{T\,d} = \frac{1}{n} \sum_{1}^{n} Td,$$

the true arithmetic mean, since, in any air mass, the variations of T and d are both small.

The mean humidity mixing ratio, $\bar{x}$, was obtained from the equation

$$\bar{x} = \frac{0 \cdot 622\,\bar{e}}{p - \bar{e}}$$

for values of $\bar{e}$ greater than 10 mb. and from the equation

$$\bar{x} = \frac{0 \cdot 622\, \bar{e}}{p}$$

for small values of $\bar{e}$.

The mean wet-bulb potential temperatures have been read off the tephigrams from the condensation curves plotted on them.

The average lapse rate of temperature between fixed heights has been calculated from values of $\bar{T}$ and h at different pressure levels. The lapse rate is considered positive when the temperature diminishes with increasing height. The dry adiabatic lapse rate is 5·4° F./1,000 ft.

Elsasser's method[9, 10], aided by his radiation chart, has been used to obtain the mean rate of cooling in different layers of the various air masses on cloudless days due to radiation (see Table IV, p. 13).

Table II is a summary of the characteristics of the selected air masses at 700 mb. (approximately 10,000 ft.) in summer and winter.

TABLE II—CHARACTERISTICS OF DIFFERENT AIR MASSES AT 700 MB.

Air mass	SUMMER Temperature Mean	Extreme max.	Extreme min.	Mean vapour pressure	Mean wet-bulb potential temperature	Mean degree of thermal stability	Mean partial thickness 1000–700 mb.	WINTER Temperature Mean	Extreme max.	Extreme min.	Mean vapour pressure	Mean wet-bulb potential temperature	Mean degree of thermal stability	Mean partial thickness 1000–700 mb.
	° F.	° F.	° F.	mb.	° F.	°F./1,000ft.	ft.	° F.	° F.	° F.	mb.	° F.	°F./1,000ft.	ft.
T_A	46	50	42	4·9	63	0·0	9,780	34	38	29	3·6	56	0·0	9,600
T_1	41	45	37	5·0	61	– 0·1	9,720	29	34	25	3·9	55	0·2	9,450
T_2	44	49	41	4·3	61	0·0	9,750	33	37	30	3·3	55	0·0	9,510
T_3	43	49	40	5·2	62	– 0·6	9,830	25	30	21	3·8	53	– 0·1	9,430
T_Q	37	42	31	5·0	60	– 0·4	9,660	24	29	19	3·2	51	0·2	9,410
H_0	41	44	36	3·8	58	0·3	9,650	26	31	21	2·9	51	0·2	9,400
A_1	..	..	..	..	..	..	..	– 8	– 4	– 13	0·7	28	0·5	8,960
A_2	..	..	..	..	..	..	..	– 3	– 1	– 4	0·8	31	1·0	9,030
P_{1c}	11	14	6	1·9	42	1·0	9,240	–14	– 7	– 22	0·5	23	1·2	8,720
P_1	19	22	14	2·8	47	0·1	9,410	– 4	1	– 10	0·8	30	0·3	9,020
P_2	19	23	17	2·6	47	0·1	9,420	0	2	– 5	1·0	32	0·6	9,090
P_3	21	26	18	3·0	49	0·0	9,460	3	7	0	1·3	37	0·2	9,140
P_4	24	27	20	3·3	51	0·3	9,520	5	10	– 1	1·4	37	0·6	9,170
P_5	25	28	21	3·6	51	– 0·1	9,540	8	12	4	1·5	40	0·1	9,240
P_6	27	30	25	4·0	53	0·2	9,570	10	14	8	1·6	40	0·3	9,270
P_7	29	32	26	4·3	55	– 0·1	9,590	16	20	12	2·6	46	0·3	9,340

§ 4—REALITY OF THE DIFFERENT AIR MASSES

A statistical test, similar to that used in the 1945 paper, has been applied to find out if the means of temperature of the different classes at corresponding levels are significant of real differences between neighbouring classes of tropical and of polar air. February has been taken to represent winter and August to represent summer. The standard deviations of the mean monthly temperatures in the free air and of the daily maximum and minimum temperatures at the surface of the different air masses are given in the thesis; their magnitude varies mainly between about 1·5° and 3·5°F.

In the free air, the test shows that there are significant differences between the neighbouring classes except between the tropical classes T_1 and T_3 above 850 mb. in August, between T_1 and T_2 below 750 mb. in February and August, and between T_Q and both T_1 and T_2 at 950 mb. in August. There is little distinction between the polar classes with cyclonic tracks and the corresponding ones with anticyclonic tracks (e.g. P_1 and P_2) at most levels in both months.

At the surface, however, significant differences exist between these classes apart from certain exceptions. There is little significant difference between the minimum temperatures of tropical classes in August, of the polar classes P_3 and P_4 in February and of P_5 and P_6 in both months. As regards maximum temperature there are no real differences between the tropical classes T_1 and T_2 and between the polar classes P_1 and P_2 in February.

There are also no real differences at the surface, although significant differences do exist in the free air, between the maximum temperatures of old polar air (P_7) and tropical maritime air (T_1) in August and between the minimum temperatures of P_7 and quasi-tropical air (T_Q).

Having regard to the fact that in the above exceptions there are one or more levels in one or both seasons when real differences do exist, all the classes set out in Table I have been retained.

PART II—DISCUSSION OF UPPER AIR DATA

§ 5—TROPICAL AIR AND ITS SUBDIVISIONS

Mean temperature and its vertical distribution.—The classes of tropical air are the warmest of all the classes selected (see Appendix I). Tropical maritime air with anticyclonic flow (T_2) is the warmest class in winter at all levels. It is also the warmest class in summer above 750 mb., but below this level the effect of the temperature of the land makes continental air (T_3) the warmest. The temperature of T_2 is definitely higher than that of tropical maritime air with straight isobars (T_1) because with anticyclonic isobaric patterns there is a predominance of occasions on which dynamical heating due to subsidence has occurred in the current on its way to the British Isles.

TABLE III—APPROXIMATE AVERAGE TEMPERATURE AT PLACES ON THE TRACKS OF TROPICAL CLASSES OF AIR MOVING TO THE BRITISH ISLES

Air mass	Approximate average surface air temperature near the source region	Approximate average temperature of the surface* over which the currents travel to the British Isles	Nature of surface on track
	° F.	° F. ° F.	
Summer (August)			
T_1, T_2	72	74 decreasing to 61	Sea
T_3	90	90 decreasing to 65	Mainly land
T_Q	62	64 decreasing to 58	Sea
Winter (February)			
T_1, T_2	58	60 decreasing to 49	Sea
T_3	57	57 decreasing to 38	Mainly land
T_Q	52	53 decreasing to 49	Sea

* Average sea temperatures are taken where track is over the sea ; average surface air temperatures are taken where the track is over land.

Authorities.—Monthly meteorological charts over the Atlantic Ocean[11]
Manual of meteorology[12]
MS. data in the Meteorological Office.

Tropical continental air (T_3), which approaches the British Isles from Spain and north-west Africa, cannot be directly compared either with tropical maritime air (T_1 and T_2) from the Azores region or with quasi-tropical air (T_Q) whose source region lies not far to the south or south-west of the British Isles. The temperature differences of these classes can be accounted for by the temperatures at places on their tracks near their source regions and the temperature of the underlying surface over which the currents travel between these places and the British Isles. These temperatures are given in Table III.

It will be seen that tropical maritime air in winter and tropical continental air in summer come from the warmest region and travel to the British Isles over the warmest surface.

The tephigrams for tropical maritime air in Figs. 4, 5 and 6 show that the curves of average temperature of these classes are, like saturated adiabatics, convex outwards towards high temperature with steeper lapse rates at low rather than at high pressures.

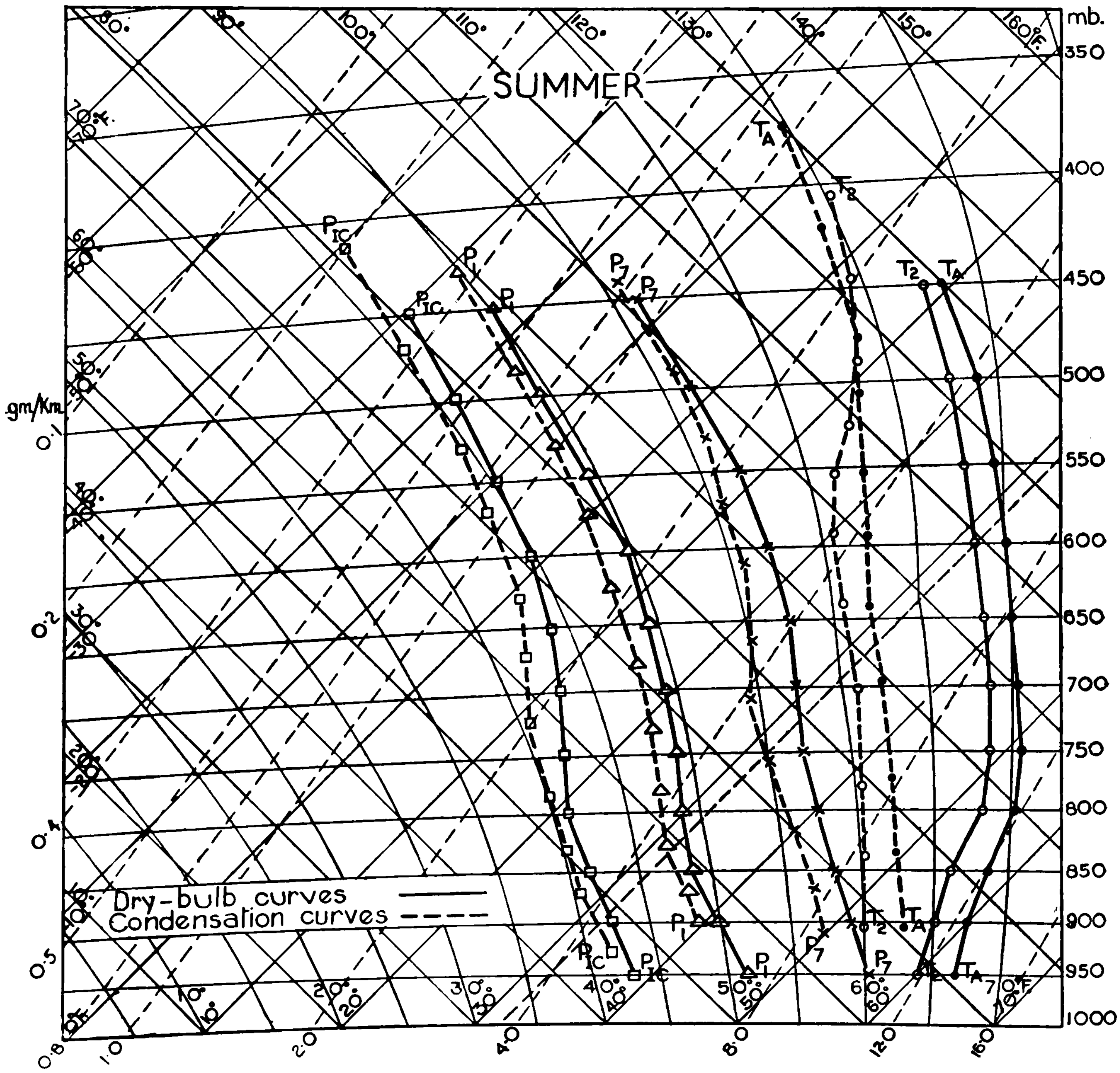

FIG. 4—TEPHIGRAMS OF AVERAGE CONDITIONS IN AIR MASSES T_A, T_2, P_{IC}, P_1 AND P_7 IN SUMMER

Appendix II shows that the lapse rate of temperature in the lower layers (down to 1,650 ft.) of tropical maritime air (T_1 and T_2) is small in both seasons. This is the effect of the underlying (sea) surface. The lower layers of these air masses lose heat to the surface layers, which in turn lose heat to the sea whose surface becomes progressively cooler towards the British Isles. The effect of the underlying land surface on the vertical distribution of temperature in the lower layers of tropical continental air (T_3) is very different. Since the land is much colder than the sea in winter and warmer in summer (see Table III) there is, in these layers of T_3, in winter an inversion and in summer a lapse rate which is much in excess of that in tropical maritime air. Fig. 6 illustrates the influence of the underlying surface on the temperature distribution in the lower layers of maritime (T_1) and continental (T_3) air.

The effect of the underlying surface on the vertical distribution of temperature in the lower layers of tropical maritime air is modified after these currents have passed inland over the British Isles. The lapse rate over the land becomes less in winter but greater in summer than

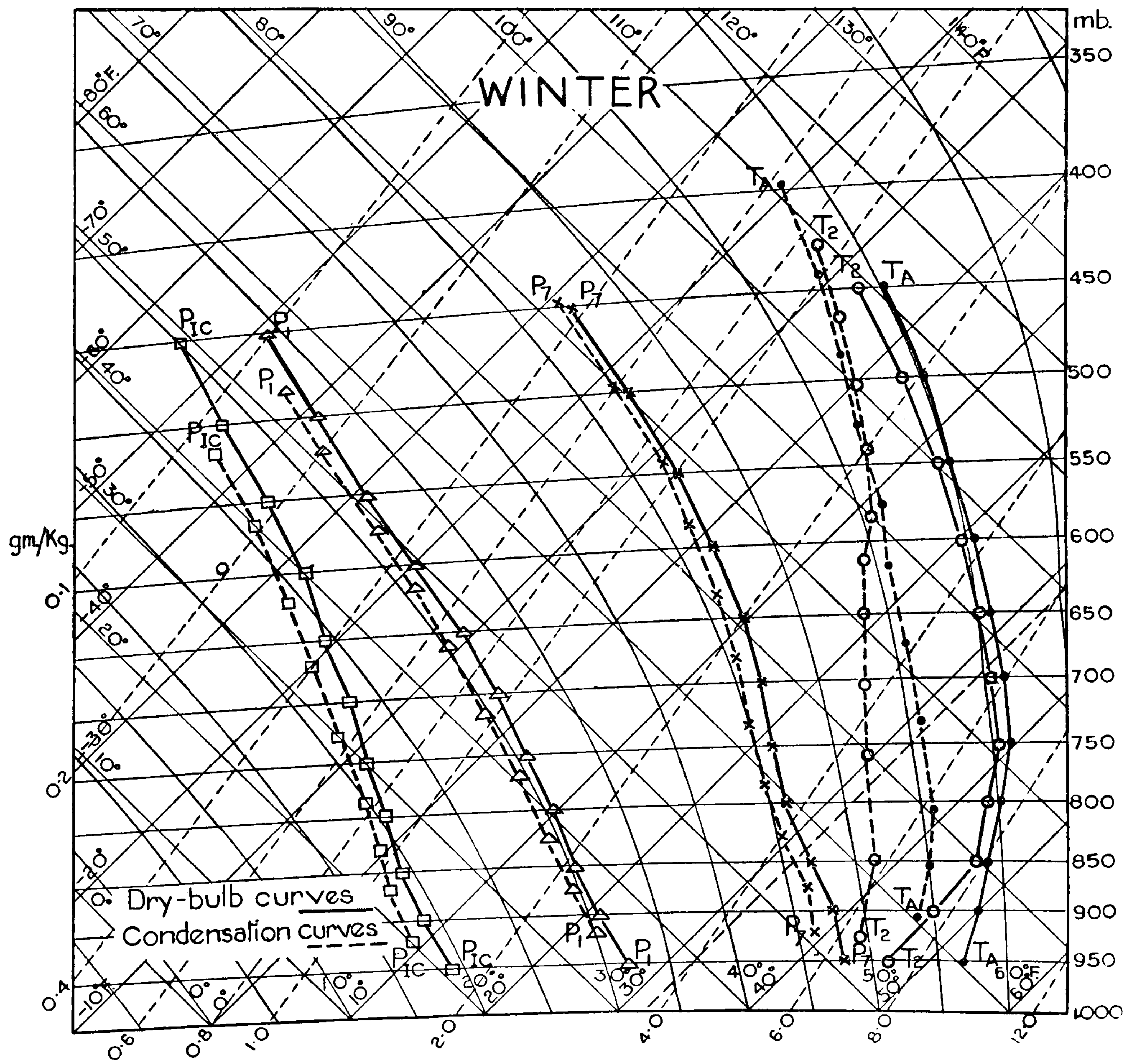

FIG. 5—TEPHIGRAMS OF AVERAGE CONDITIONS IN AIR MASSES T_A, T_2, P_{1C}, P_1 AND P_7 IN WINTER

it is over the sea. Thus, in the morning, the lapse rate between 950 mb. and 900 mb. in T_1 is, on the average, about 1° F./1,000 ft. greater in winter and about 0·5° F./1,000 ft. less in summer on the coast (Penzance) than it is inland (Downham Market).

Table IV shows that on cloudless days radiative cooling tends to increase the lapse rate just above the lowest layers of all the tropical maritime classes in both seasons and of tropical continental air (T_3) in winter.

The lapse rate in tropical air increases with increasing height (Appendix II), and above about 700 mb. exceeds the saturated adiabatic rate in all classes in summer as well as in T_2 in winter. Owing to the stability of the surface layers of the maritime classes (T_1 and T_2) and of the continental class (T_3) in winter there can be no large-scale convection or condensation of water vapour in the upper and middle layers of those air masses. The only agents affecting the vertical distribution of temperature in these layers must be long-wave radiation from the earth's surface and troposphere, mechanical turbulence due to wind shear, convectional turbulence due to

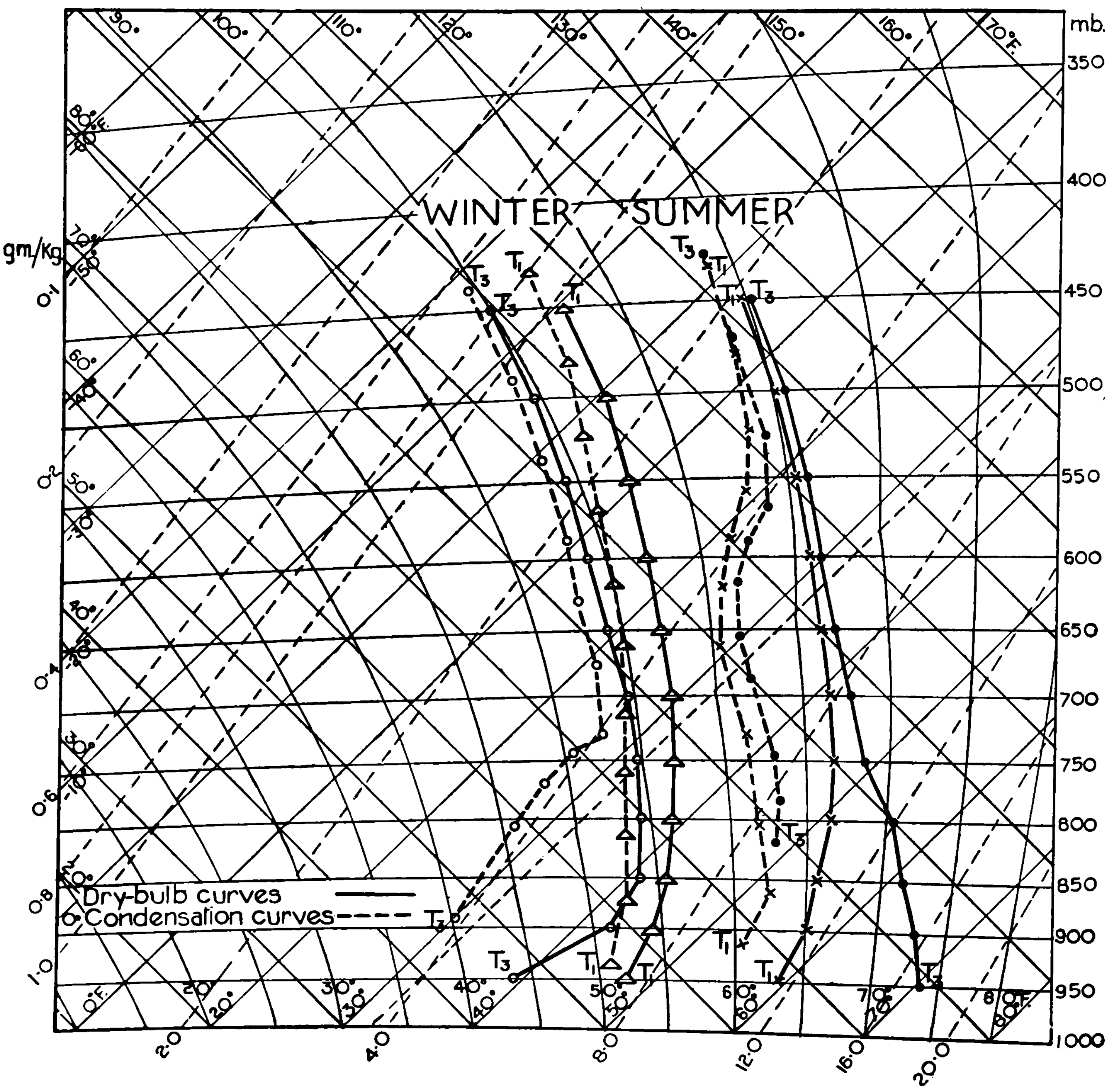

FIG. 6—TEPHIGRAMS OF AVERAGE CONDITIONS IN TROPICAL MARITIME (T_1) AND TROPICAL CONTINENTAL (T_3) AIR IN SUMMER AND WINTER

TABLE IV—AVERAGE RATE OF RADIATIVE COOLING ON CLOUDLESS DAYS

Layer	Air mass T_A	T_1	T_2	T_3	H_0	P_{IC}	P_1	P_3	P_5	P_7
mb.	*degrees Fahrenheit in 24 hours*									
	SUMMER									
700–500	3·4	3·5	3·3	3·3	2·9	2·0	2·2	2·7	2·7	2·8
900–700	4·2	4·0	4·0	3·8	3·4	3·1	3·2	3·6	3·8	3·9
Ground–900	3·7	2·9	3·6	4·3	3·8	4·5	4·6	4·3	4·0	4·0
	WINTER									
700–500	3·2	3·3	3·2	3·2	3·4	1·4	1·5	1·8	2·3	2·6
900–700	4·0	4·1	3·9	3·3	3·3	1·9	2·6	2·7	3·0	3·3
Ground–900	3·3	2·6	2·5	2·4	2·5	3·1	3·4	3·7	3·9	4·2

buoyancy[13], and subsidence in the anticyclonic class (T_2). Radiation, which heats the lower layers more than it does the higher layers, will increase the lapse rate as will mechanical turbulence, which transfers heat from high to low potential temperature. On the other hand, convective turbulence, which transfers heat from high to low temperature, would diminish the lapse rate. Subsidence of moist air will increase the lapse rate in the upper part of the subsiding layer and decrease it in the lower part[14].

Now tropical air is not saturated at high levels (see tropical-air condensation curves of Figs. 4–6). The relative humidity in the different classes at 500 mb. ranges from 53 to 69 per cent. in summer and from 64 to 86 per cent. in winter. Hence subsidence and radiation would tend to produce a lapse rate nearer the dry-adiabatic than the saturated-adiabatic rate. The lapse rate found shows that convective turbulence must affect the vertical temperature distribution in the upper layers of tropical maritime air.

The lapse rate in the upper and middle layers of tropical continental air in summer increases with altitude, and exceeds the saturated adiabatic rate (Fig. 6). It is not improbable that the lapse rate found would be higher were it not for infra-red radiation which has a stabilizing influence.

The mean partial thicknesses at 700 mb. and 500 mb. are given in Table V.

TABLE V—MEAN PARTIAL THICKNESSES

Thickness	Air mass T_A	T_1	T_2	T_3	T_Q	H_0
mb.	*feet*					
	SUMMER					
700–500	8,840	8,780	8,820	8,780	8,630	8,790
1000–700	9,780	9,720	9,750	9,830	9,660	9,650
	WINTER					
700–500	8,610	8,470	8,540	8,450	8,430	8,490
1000–700	9,600	9,450	9,510	9,430	9,410	9,400

Water vapour and humidity.—In both seasons the mean amount of water vapour present in the troposphere is greatest in the tropical classes. This is indicated by Table VI which gives the average amount of precipitable water present in the atmosphere in different air masses.

Although the water-vapour content of the tropical classes is greater than that of the polar classes (see Appendix I), yet in the middle and upper layers of the tropical classes relative humidities are lower (compare, from the condensation curves of tropical air and polar air in Figs. 4–6, the amounts of adiabatic reduction of pressure required to produce saturation). Tropical maritime air becomes saturated or nearly so at the top of the surface turbulent layer, but in its upper and middle layers only when situated well inside the warm sector where precipitation occurs[15].

TABLE VI—AVERAGE AMOUNT OF PRECIPITABLE WATER IN THE LAYER 950–450 MB.

Season	T_A	T_1	T_2	T_3	T_Q	H_0	P_{IC}	P_1	P_2	P_3	P_4	P_5	P_6	P_7
							grams per square centimetre							
Summer	2·6	2·6	2·4	2·5	2·4	1·9	0·9	1·3	1·2	1·5	1·6	1·7	1·8	2·0
Winter	1·8	1·8	1·5	1·4	1·4	1·0	0·3	0·4	0·6	0·7	0·7	0·9	0·8	1·3

The average relative humidities in the middle and upper layers of T_2 are low in comparison with those of T_1. This is the effect of subsidence in T_2.

Table VII shows the percentage increase of the average humidity mixing ratio in summer over that in winter.

TABLE VII—PERCENTAGE INCREASE OF HUMIDITY MIXING RATIO IN SUMMER OVER THAT IN WINTER

Pressure	T_A	T_1	T_2	T_3	T_Q	P_{IC}	P_1	P_2	P_3	P_4	P_5	P_6	P_7
mb.						*percentage increase*							
500	55	91	59	100	73	363	450	133	250	327	229	300	114
600	71	68	60	90	53	330	300	158	162	192	147	224	88
700	37	29	34	35	55	337	273	151	125	134	134	157	80
800	29	56	62	47	75	251	194	158	121	95	92	96	60
900	28	45	45	108	76	256	136	130	84	87	80	80	57
950	53	42	47	129	69	234	123	136	89	78	81	86	54

It will be seen that the percentage increase in tropical maritime air (T_1, T_2) and in all but the lowest layers of tropical continental air (T_3) is less than in the polar classes with the exception of the lowest layers of the oldest class P_7. This is because the evaporation from the surface is less in tropical maritime and old polar air than in other classes of air. At the surface, the annual range of maximum temperature is less (Appendix IV), and the mean daily relative humidity in summer slightly greater in tropical maritime and old polar air than in the other polar classes or in tropical continental air. Again, Table VII shows that the difference between the percentage increase of the humidity mixing ratio in tropical maritime air and that in the polar classes increases with altitude. Owing to the greater stability of the lower layers of tropical maritime air, water vapour is not transported to high levels by large-scale convection as it is in the polar classes.

§ 6—POLAR AIR AND ITS SUBDIVISIONS

Mean temperature and its vertical distribution.—The subdivisions of polar air, set out in Table I, arise from the different degrees of modification to which this air has been subjected on its way to this country. Other things being equal, the degree of modification depends upon the time and length of the journey taken by the air to reach the British Isles from its source regions in the Arctic. In general, the more direct and rapid the journey the less is the air modified. It is therefore possible to speak of the age of polar air and to consider it young or old according to its trajectory and speed. Fig. 2 shows that the youngest polar air is P_1, air of a direct polar outburst, and the oldest P_7, air which arrives over this country from the south-west after having travelled south-eastwards to the south of latitude 45° N.

When polar air leaves its source regions to journey into lower latitudes, it absorbs heat and moisture since it travels over a surface (sea) which is always warmer than itself. An examination of the distribution of temperature of the surface of the North Atlantic in February and August, given in " Monthly meteorological charts of the Atlantic Ocean "[11], in relation to the trajectories of polar air shown in Fig. 2, shows that the temperature of the underlying sea surface, over which polar air from the north and north-west (P_1 and P_3) travels, continues to increase until the air reaches the British Isles. For eastward-moving air (P_5), this increase is very small for a considerable distance to the west of Ireland. In the case of the oldest polar air (P_7) there is also a net increase, and this is greater than that of the other classes, yet in the last stages of its journey the temperature of the underlying surface of P_7 falls. It is because P_7 and tropical maritime air (T_1) approach the British Isles on very similar sea routes that the differences between the mean temperatures of their lowest layers are small.

The effects of the temperature of the underlying surface and of the time spent on the journey to this country influence both the temperature and moisture content of polar air. These, as shown in Appendix I and by the temperature and condensation curves of P_1 and P_7 in Figs. 4 and 5, increase at all levels as the polar air ages. In both seasons, P_1 is the coldest of the maritime classes with the least amount of water vapour while P_7 is the warmest with the largest amount of water vapour. In winter, polar continental air (A_1) is colder than P_1, because the track of A_1 lies mainly over the land surface which is then ice-bound or snow-covered.

Appendix I shows that the temperature increase of polar air with age is, at all heights, greater in winter than in summer. This is because the seasonal difference in the amount of heat absorbed from the surface by the older polar classes is less than that absorbed by the younger classes. In the oldest polar air (P_7), which remains for a considerable time over the North Atlantic, the seasonal difference in the heat absorbed will mainly depend upon the annual range of temperature of the sea surface to the west and south-west of the British Isles. This range is only about 10° F. On the other hand, in the youngest and most direct polar air (P_1) the seasonal difference in the amount of heat absorbed will, to a much greater extent, depend upon the difference between the annual range of temperature in the Arctic, north of 70° N., and that of the sea surface off the north coasts of the British Isles. This difference has an average value (for different longitudes) exceeding 30° F.[12]

The temperature of a polar anticyclonic class (air moving on an anticyclonic track, e.g. P_2) is, level for level except near the surface, generally higher than that of the corresponding cyclonic class (air moving on a cyclonic track, e.g. P_1). This is because dynamical heating due to subsidence occurs in the anticyclonic class. The similarity of origin of corresponding cyclonic and anticyclonic classes is revealed by the close agreement of their wet-bulb potential temperatures (see Appendix I).

In the tephigrams of Figs. 4 and 5 the curves of average temperature in polar air, unlike those in tropical air, are convex towards low temperature in a layer between 900 mb. and 700 mb. The polar temperature curves above and below this layer show greater lapse rates than do the tropical temperature curves.

Since polar air gains heat from the surface during its journey to lower latitudes, the lapse rate of temperature at all heights, especially in the lowest layers, exceeds, in both seasons, that in tropical maritime air and in tropical continental air in winter (Appendix II). When polar air travels inland over the British Isles the temperature of the lowest layer continues to rise in summer, especially in the afternoon, and to fall in winter, particularly during the night and early morning. The effect of these changes of temperature upon the layer between 950 mb. and 900 mb. when these currents pass inland in the morning is, in winter, to decrease the lapse rate by about 0·8° F./1,000 ft. in direct polar air (P_1) and by 1·9° F./1,000 ft. in polar continental air (A_1) ; and, in summer, to increase it by 1·4° F./1,000 ft. in P_1.

The effect of the relatively warm underlying sea surface on the vertical distribution of temperature in the lowest layers of direct polar air (P_1) and of polar continental air (A_1) with a long track over the North Sea in winter is to produce a very high lapse rate in these layers by the time the currents reach the coasts. This lapse rate has, on occasions, exceeded the dry-adiabatic rate.

In the polar cyclonic classes the relatively high lapse rate in the layer between 1,650 and 3,300 ft. in the morning in summer (Appendix II) may be accounted for by the persistence throughout the night of the high lapse rate of unsaturated air developed there during the previous afternoon.

The vertical distribution of temperature in the upper and middle layers of polar air is influenced, as it is in tropical air, by the transfer of heat by long-wave radiation and eddy motion (mechanical and convectional turbulence) and, in the anticyclonic classes, by dynamical heating due to subsidence. The lapse rate is also affected, owing to the instability of the lowest layers, by large-scale convection, which will transport heat upwards. If, as a result of convection, condensation of water vapour occurs the latent heat of condensation will be released. If precipitation ensues, there will be a loss of heat due to the cooling of the air by the evaporation of this precipitation. The air will also be cooled by the melting of snow and hail. It is not possible to assess the contribution which each of these factors makes to the vertical distribution of temperature. Owing to the prevalence of cloud in polar air, the effect of long-wave radiation must be small. Appendix II shows that in the middle troposphere the lapse rate increases with height less uniformly in polar than in tropical air ; between about 950 mb. and 700 mb. the lapse rate is diminished or remains almost constant in polar air. This is because water vapour is condensed in this layer. The base of this layer is higher in summer than in winter, since, over the land, water vapour is condensed at higher levels in summer than in winter.

In the highest layers the lapse rate in polar air exceeds that in tropical air, but it is only in the older cyclonic classes that the saturated adiabatic rate is approached or exceeded.

The mean partial thicknesses at 700 mb. and 500 mb. are given in Table VIII.

TABLE VIII—MEAN PARTIAL THICKNESSES

Thickness	Air mass									
	P_{1C}	P_1	P_2	P_3	P_4	P_5	P_6	P_7	A_1	A_2
mb.	*feet*									
	SUMMER									
700–500	8,230	8,330	8,330	8,400	8,440	8,430	8,520	8,540	..	..
1000–700	9,240	9,410	9,420	9,460	9,520	9,540	9,570	9,590	..	..
	WINTER									
700–500	7,750	7,910	8,120	8,040	8,130	8,150	8,240	8,290	7,840	8,000
1000–700	8,720	9,020	9,090	9,140	9,170	9,240	9,270	9,340	8,960	9,030

Water vapour and humidity.—At all heights vapour pressure increases with the age of the polar air (see Appendix I). The increase in water-vapour content is, however, much greater at low than at high levels. Thus between P_1 and P_7 this increase in summer is 3·0 gm./m.^{3} at 950 mb. and 0·3 gm./m.^{3} at 450 mb.

Above the lowest layers the maximum vertical gradient of vapour pressure generally occurs at a lower level in the polar classes than it does in the tropical classes.

The condensation of water vapour, the evaporation of precipitation and the melting of snow and hail in polar air give rise to relative humidities which are greater than in tropical air. In the lowest layers relative humidities in the polar cyclonic classes (e.g. P_3) are generally lower in winter and higher in summer than in the corresponding anticyclonic classes (e.g. P_4). At greater heights the cyclonic classes usually have a higher relative humidity than the anticyclonic classes. At some levels in the highest layers humidities approach saturation in the oldest cyclonic classes (Figs. 4 and 5).

§ 7—ANTICYCLONIC (INDETERMINATE) AIR

Mean temperature and its vertical distribution.—The data for this class (H_0) are from soundings made in, or slightly to the north of, the central region (as determined by the surface pressure distribution) of quasi-stationary anticyclones. The temperature and condensation curves of this class are given in Fig. 7.

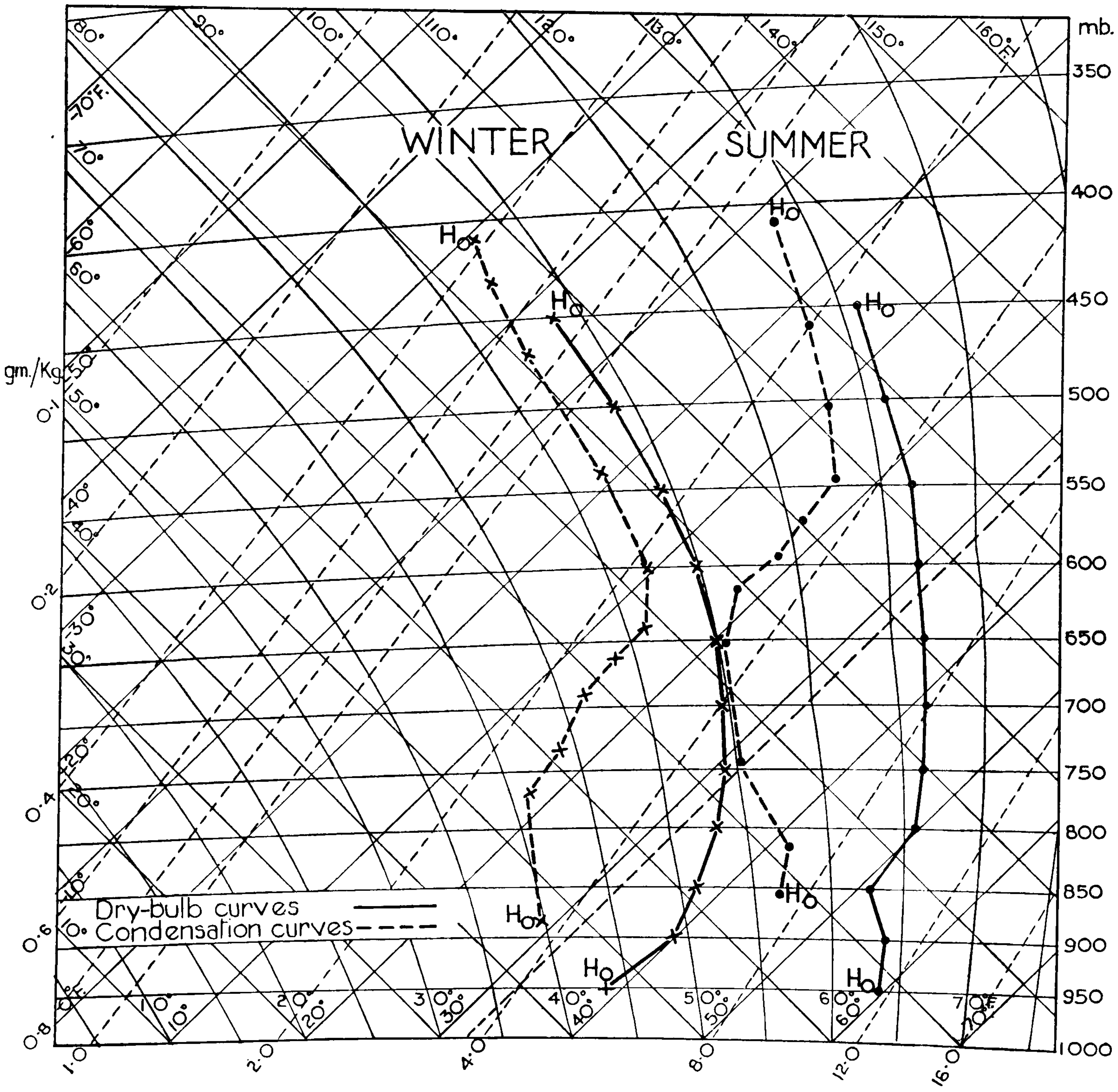

FIG. 7—TEPHIGRAMS OF AVERAGE CONDITIONS IN ANTICYCLONIC (INDETERMINATE) (H_0) AIR IN SUMMER AND WINTER

Appendix I shows that in summer the temperature of the air above 600 mb. is only exceeded by that of tropical maritime air with anticyclonic isobaric patterns (T_2) ; below 600 mb. the temperature of H_0 is lower than that of the tropical classes but higher than that of quasi-tropical air and of the oldest polar air. This is also the case in winter at all levels except the lowest (see Appendix I).

A comparison of the tephigrams in Figs. 4 and 5 with those in Fig. 7 shows that the curves of temperature of H_0 are very similar in shape to those of the tropical maritime class (T_2). The curves of H_0 are for average values, and so mask layers in which there are inversions above which are shallow layers with high lapse rates.

As in tropical continental air (T_3), the lapse rate of temperature in the lowest layers of H_0 is much affected by the underlying surface ; this, for the slow-moving air of this class, is mainly land. In consequence, the lapse rate in the lower layers is very different in winter from what it is in summer. In winter there is an inversion ; in summer the temperature curve is convex towards the high temperature, though at night there is also an inversion near the ground. The high lapse rate above 950 mb. in the early morning in summer is probably the remains of the high lapse rate, often almost the dry adiabatic, established during the early afternoon of the previous day.

The same agents which affect the distribution of temperature in the upper and middle layers of tropical maritime air (T_2) also affect the temperature distribution in the same layers of H_0. The amount of dynamical heating must be about the same as in tropical maritime air with anticyclonic flow (T_2) since subsidence in a well established anticyclone is small[16]. As the amount of water vapour present in H_0 is less than in T_2 (see Appendix I) the effect of infra-red radiation will be less. Appendix II shows that in the middle and upper layers of H_0 the lapse rate increases with increasing heights. At the greatest heights the lapse rate is very similar to that in tropical maritime air (T_2) in that it is less than in polar air but approximates to, or exceeds, the saturated adiabatic rate.

The mean partial thicknesses at 700 mb. and 500 mb. are shown in Table V, p. 13.

Water vapour and humidity.—The amount of water vapour present in H_0 is less than in tropical air but exceeds that in all but the oldest of the polar classes (see Table VI, p. 14).

The water-vapour content, as expressed by the absolute humidity, varies little in the layer between the levels 900 mb. and 700 mb. in winter and in the layer between 800 mb. and 600 mb. in summer (see condensation curves of Fig. 7). The differences in water content between the top and bottom of these layers are respectively 0·4 gm./m.^{3} and 0·7 gm./m.^{3} In these layers also, the average relative humidity is low. Neglecting turbulent mixing, it would appear that subsidence has brought to the lower levels of these layers the values of absolute humidity appropriate to that of their upper levels.

Below these layers both relative and absolute humidities rapidly increase. This indicates that much of the moisture acquired at the surface by evaporation is confined to the friction layer owing to the thermal stability of this layer.

§ 8—COMPARISON BETWEEN THE TEMPERATURE OF DIFFERENT AIR MASSES

Appendix I shows that, above 750 mb., the average summer temperature in all polar classes is less than the average winter temperature in the tropical maritime classes. It also shows that the rise of temperature from winter to summer is greater in polar than in tropical maritime air and that this rise diminishes with the age of the polar air, there being little difference between P_7 and T_1 in this respect.

It is of interest to note that in the upper air over the British Isles mean monthly temperatures reach their maximum in tropical air, old polar air (P_7) and in indeterminate anticyclonic air (H_0) in August, and in all the remaining polar classes in July ; they attain their minimum in tropical maritime air mainly in March and in all other classes in February.

§ 9—DEGREE OF THERMAL STABILITY FOR SATURATED AIR

If, at any level, L is the lapse rate of temperature and L_S the saturated adiabatic rate, then b, the degree of thermal stability for a parcel of ascending saturated air can be expressed in degrees Fahrenheit per 1,000 ft. by the equation

$$b = (L_S - L).$$

Further, according as the atmosphere is thermally stable, unstable or in convective equilibrium for ascending saturated air, so b is respectively positive, negative or zero. Mean values of b at different pressure levels in different classes of air are set out in Appendix I. Values of L at any pressure p are the mean of the values of L in the layers $(p + 50)$ mb. and $(p - 50)$ mb. Values of L_S at different pressure levels have been obtained from the diagram of isopleths of L_S given by Brunt[17].

In both summer and winter, the polar classes are thermally unstable in a layer whose base is on the surface during the day-time. During the night and early morning this instability does not extend down to the ground except on the coasts and inland when the sky is clouded and the wind strong. The top of this layer extends to greater heights in the cyclonic than in the corresponding anticyclonic classes, in summer than in winter, and also in polar air, with the exception of the oldest polar air (P_7) in winter, the older the polar air becomes. This is because the surface heating is greater in these cases. As regards P_7 in winter, this current travels during the last part of its journey over a progressively colder sea surface. The polar classes, with the exception of the older cyclonic classes in summer, are thermally stable in their upper layers. Unlike polar air, anticyclonic air (H_0) is thermally unstable in the highest layers. So also are all the tropical classes in summer as well as the tropical maritime class T_2 in winter.

With diminishing height the tropical classes, with the exception of continental air (T_3) in summer, experience increasing thermal stability. Near the surface the degree of stability is higher, particularly in tropical continental air (T_3) and in anticyclonic air (H_0) in winter. During summer afternoons all the tropical classes as well as anticyclonic air become, when inland, unstable in their lowest layers. In this season tropical continental air (T_3) is unstable at all heights.

Appendix I gives the mean wet-bulb potential temperature of the different classes. With the exception of tropical continental air (T_3) in summer, the mean stratification in tropical air is stable except near the ground on summer afternoons. In summer T_3 is potentially unstable in the layer between 950 mb. and 700 mb. ; owing to its dryness this layer would have to be lifted over 100 mb. to become saturated. Real latent instability in this layer can only be established by the addition of 4 gm. of water vapour per kilogram of dry air.

Tropical maritime air (T_1), when situated well inside a warm sector, displays stable stratification apart from a few isolated shallow layers which are potentially unstable[15].

In polar air at night and in the early morning the stratification near the ground is stable in both seasons, the degree of stability being greatest in the anticyclonic classes in winter. Instability prevails in this layer for most of the daylight hours.

In summer, there is real latent instability in the lower layers of polar air while conditional instability prevails in the upper layers of all but the youngest of the polar classes. In winter, only the lower layers display conditional instability of the pseudo-latent type. In the upper layers the stratification is stable.

§ 10—CHANGES OF TEMPERATURE, HUMIDITY AND STABILITY IN MOVING TROPICAL MARITIME AND DIRECT POLAR AIR

A comparison was made between average conditions in tropical maritime air (T_A) over the Azores region and over the British Isles (T_2), both currents with anticyclonic tracks, and between direct polar air (P_{1C}) over the Icelandic region and over the British Isles (P_1), both currents with cyclonic tracks.

There is a difficulty in the physical interpretation of the changes occurring in a moving air mass whether the comparison is made at fixed geometrical levels or at fixed pressures. Even if the air which was at the surface at the Azores is still at the surface on its arrival at the British Isles the effect of temperature changes in the air mass will cause the air at, say, 15,000 ft. over the Azores to reach the British Isles at a different level. Again, the air at, say, 800mb. at the Azores would not of necessity be at this pressure on reaching the British Isles owing to convergence or divergence at another level. Here comparisons have been made at fixed pressures.

Tropical maritime air.—Appendix I shows that in summer above 900 mb. and in winter above 800 mb. the differences between the wet-bulb potential temperatures of T_A and T_2 are small, not exceeding 2·0° F., so that these classes are almost identical. Below these levels the differences increase and are the effects of the underlying surface.

A comparison of the temperature curves of classes T_A and T_2, given in Figs. 4 and 5, brings out the heat lost by tropical air on its way to the British Isles. Appendix I shows that in the layer between 850 mb. and 500 mb. the average decrease of temperature ($T_A - T_2$) is about 2° F. in summer and 1° F. in winter. Wind speed increases with height and is, at all heights, greater in winter than in summer. If then the times taken to reach the British Isles from the Azores at levels 800 mb. and 600 mb. be estimated as respectively 48 hours and 40 hours in summer and 30 hours and 25 hours in winter, the above falls of temperature can, to a great extent, be accounted for by the difference between dynamical heating due to subsidence, amounting to about 500 feet per day, and cooling due to infra-red radiation, supposing the current cloudless (see Table IV, p. 13). Below 850 mb. the heat lost by tropical air increases as the surface is approached. This is shown in Table IX.

TABLE IX—AVERAGE DECREASE OF TEMPERATURE IN TROPICAL MARITIME AIR BETWEEN THE AZORES AND THE COASTS OF SOUTH-WEST ENGLAND

	Average decrease of			
	Sea temperature	Air temperature Surface	950 mb.	900 mb.
	degrees Fahrenheit			
Summer	11	9	3	2
Winter	10	8	5	3

It will be seen that the decrease of temperature in the surface layers approximates to that of the surface of the sea over which tropical air moves. Above the surface, the fall of temperature is a little greater in winter than in summer probably because of stronger winds in winter.

The lapse rate of temperature changes but little at all levels in summer and above 6,600 ft. in winter. Below this level in winter the lapse rate has been reduced by nearly 2° F./1,000 ft. owing to the cooling effect of the sea (see Appendix II).

There are only minor differences in the degree of thermal stability for saturated air at all levels in summer, and above 850 mb. in winter. Below 850 mb. in this season T_2 becomes decidedly more stable than T_A (see Appendix I).

A comparison of the condensation curves of T_A and T_2, given in Figs. 4 and 5, shows that in both, in summer and winter and above the level of about 600 mb., the moisture content, as indicated by the humidity mixing ratio, is slightly less over the British Isles than over the Azores.

Direct polar air.—Appendix I shows that at all heights the wet-bulb potential temperature in direct polar air over the British Isles (P_1) exceeds that in the same air mass over the Icelandic region (P_{IC}). This is due to heat and moisture absorbed from the surface and transported to high levels as the current proceeds southwards. The increase in the wet-bulb potential temperature is less in summer than in winter because the temperature difference between the air and the sea surface in the Icelandic region is much less in summer than in winter.

A comparison of the temperature and condensation curves of classes P_{IC} and P_1, given in Figs. 4 and 5, brings out the average gain of heat and moisture absorbed by direct polar air during its journey to the British Isles. The rise of temperature is greater in winter than in summer and in both seasons it decreases with increasing height.

The rise of the surface air temperature in direct polar air as it proceeds from the Icelandic region to the north-west of Scotland can approximately be accounted for by the warming effect of the ocean between these regions. Table X shows that the differences between the observed and calculated rises of temperature of the air due to this effect are small.

TABLE X—CALCULATED AND OBSERVED CHANGES OF TEMPERATURE AT THE SURFACE IN DIRECT POLAR AIR BETWEEN SOUTH-EAST COASTS OF ICELAND AND NORTH SCOTLAND

	Rise in sea temperature	Mean sea temperature	Mean surface air temperature in P_{IC} Over land	Over sea	Calculated* change of temperature	Mean air temperature in P_1, north Scotland	Observed change of temperature
	$\Delta\theta_s$	θ_s	θ_a	θ'_a	$0{\cdot}6\ (\theta_s-\theta_a)$	θ_a''	$\theta_a''-\theta_a$
	° F.	° F.	° F.	° F.	° F.	° F.	° F.
Summer ..	6	52	46	46	4	50	4
Winter ..	6	42	16	26	16	33	17

* The calculated difference, $\theta_a'' - \theta_a$, has been derived from the equation $\theta_a''-\theta_a = 0{\cdot}6\ (\theta_s - \theta_a)$ obtained by Frost[18].

The temperature of the sea surface to the east of Iceland is very high, especially in winter, in comparison with that in direct polar air. Hence in this region, direct polar air (P_{IC}) has already developed a high lapse rate in its lowest layers. On the other hand, mean temperatures in direct polar air (P_1) over the British Isles have been obtained mainly from inland stations and in the morning when the underlying surface is cold. Hence, although the temperature of the sea surface increases between the Icelandic region and the British Isles ($\Delta\theta_s$ in Table X), there is little difference between the lapse rate in P_{IC} and P_1. Indeed, in winter, the lapse rate in the lowest layers has decreased ; in the upper layers the lapse rate in P_1 is slightly greater than that in P_{IC} (see Appendix II). It is only in the lower layers that the stability for saturated air has increased. At higher levels the air has become less stable.

The moisture content increases as the current proceeds southwards, this increase being greater in summer than in winter (Figs. 4 and 5).

The changes developed in the physical properties of direct polar air are considerably greater than those developed in tropical air. This is because the temperature changes of the sea surface over which these air masses travel to the British Isles give rise to increasing thermal instability in polar air and to increasing thermal stability in the lowest layers of tropical maritime air.

PART III—DISCUSSION OF SURFACE DATA

§ 11—TEMPERATURE

The dependence of temperature upon air mass is brought out in the monthly and seasonal tables (Appendices III and IV); for example, the mean temperature (mean of maximum and minimum temperatures) of tropical maritime air (T_1) in January exceeds that of direct polar air (P_1) in May.

The range of mean temperature amongst the classes of air is greater in winter than in summer. In January, mean temperature is lowest in polar continental air A_1 (28° F.) and highest in tropical maritime air (51° F.). In July, direct polar air P_1 is coldest (58° F.), tropical continental air T_3 warmest (71° F.).

Appendix IV shows that, in winter, mean temperature exceeds the normal (for the 70 years 1871–1940) in tropical air, in the oldest polar air and in the anticyclonic class H_{SW}. Mean temperature increases with the age of the polar air. There is little difference between the mean temperature of tropical maritime air (T_1) and of the oldest polar air (P_7) in summer; it will be remembered that T_1 and P_7, in the final stages of their journey, travel along the same route (see Figs. 1 and 2). The mean temperature of the polar cyclonic class from the north-west (P_3) in winter and from the west (P_5) in summer are closest to the normal. The mean temperatures of the anticyclonic classes (H_{NW}, H_{NE}, H_{SE}, and H_0) exceed the normal in summer and are below it in winter. This is because the underlying surface is mainly a land one and because skies are clearer in these classes in summer. The mean temperature of tropical maritime air (T_1) exceeds that of tropical continental air (T_3 and T_4) in winter, the reverse being the case in summer. In T_1 the sky is more clouded than in T_3 or T_4; also the underlying surface of T_1 is mainly sea, that of T_3 and T_4 mainly land.

The mean daily range of temperature of all classes is less in winter than in summer owing to less insolation, more clouded skies and the greater coefficients of conductivity and heat capacity of the ground in winter than in summer.[19] The mean daily range is greater in slow-moving anticyclonic air and in tropical continental air than in tropical maritime air and the polar classes, since this range is greater over a land than over a sea surface. The formation of large amounts of convection cloud and the cooling of the air by the evaporation of the instability precipitation, so common in the polar cyclonic classes at the time of maximum temperature, are important

TABLE XI—EXTREMES OF TEMPERATURE AT KEW, 1871–1948

Month	Highest maximum				Lowest maximum				Highest minimum				Lowest minimum			
	Temperature	Air mass	Date Day	Date Year	Temperature	Air mass	Date Day	Date Year	Temperature	Air mass	Date Day	Date Year	Temperature	Air mass	Date Day	Date Year
	° F.				° F.				° F.				° F.			
January ..	57	T_2	2	1922	22	A_1*	5	1894	53	T_2	3	1922	9	P_2*	17	1881
February ..	62	T_2*	10	1899	23	A_2*	9	1895	52	H_{SW}	10	1939	11	A_1*	7	1895
March ..	69	H_0	23	1945	31	A_1	9	1933	52	T_2	25	1912	17	P_1	5	1909
April ..	80	T_3*	20	1893	35	P_1	5	1911	55	T_3	15	1945	26	P_2	2	1922
May ..	87	T_3	{24, 29}	{1922, 1944}	46	P_2*	1	1877	63	H_{SE}	30	1944	30	H_{NE}*	5	1877
June ..	91	T_3	3	1947	50	P_1	19	1903	65	T_3	25	1935	37	{P_2*, P_2*}	5, 3	1880, 1923
July ..	91	T_3	31	1943	54	P_1	5	1920	68	T_3	29	1948	43	{P_2*, H_{NW}}	1, 11	1882, 1907
August ..	94	T_4	9	1911	55	P_2*	7	1898	67	H_{SE}	13	1911	41	H_{NW}*	31	1890
September ..	92	T_4	1	1906	48	P_1	29	1918	64	T_2	2	1932	31	H_{SE}	30	1919
October ..	82	T_3	5	1921	38	P_2*	29	1873	61	T_1	{6, 10}	{1916, 1933}	25	P_1*	28	1895
November ..	66	T_2	5	1938	25	P_1*	28	1890	58	T_2	5	1938	20	H_0*	19	1871
December ..	59	T_1	4	1931	22	A_2*	14	1890	53	T_1	4	1934	11	H_0*	22	1890

* Estimated.

factors in producing a daily range which, in both seasons, is less in these classes than in the corresponding anticyclonic ones. A contributory cause of the very small daily range in tropical maritime air (T_1) is the incidence of much low cloud due to eddy motion. This cloud, except in summer afternoons, often completely covers the sky and persists throughout the 24 hours of the day.

Table XI gives, for the period 1871–1948, the absolute highest and lowest maximum and minimum temperatures in each month recorded at Kew together with the dates and the air masses in which these extremes occurred. It shows, incidentally, that ice days at Kew (days when the maximum temperature does not exceed 32° F.) can occur in polar continental or direct polar air from November to March, and that it is only in June, July and August that the minimum temperature in polar air has not fallen to 32° F. or less. The extreme annual range of temperature is 85° F.

§ 12—WATER VAPOUR

Appendix V shows that the average daily vapour pressure in both seasons exceeds in the tropical classes, in the anticyclonic classes H_0 and H_{SW} and in the oldest polar air the normal of all classes of air combined. In the anticyclonic classes, moisture acquired from the surface by evaporation is concentrated in the very stable lowest layers.

Fog or mist is likely to occur during quiet clear nights in those classes whose average minimum temperature is below that of their average dew point. Thick fog is therefore very probable in winter in the anticyclonic classes H_0 and T_4.

The average mean daily relative humidity is highest in winter in the anticyclonic class H_0 and in tropical air. This is due, in H_0, to radiative cooling and the concentration of water vapour in the lowest layers, and in tropical air to the effect of progressive cooling of the surface layers together with the very slow upward transport of water vapour.

The mean daily relative humidity in polar air with a cyclonic track is slightly lower in winter but higher in summer than in the corresponding anticyclonic class.

In the period 1931–45 the lowest relative humidities recorded at Kew were 10 per cent. at 1515 on April 15, 1942, 13 per cent. at 1800 on June 3, 1939, and 16 per cent. at 1300 on July 10, 1934, all in the air of the anticyclonic class H_{NE} (Drummond[20]).

§ 13—INCIDENCE OF THE DIFFERENT AIR MASSES

The class of air at the surface at 1800 G.M.T. has been determined at Kew, Scilly and Stornoway for every day of the period 1938–49. So that each day shall have a class assigned to it, it was necessary to add four classes to those given in Table I. These are :—

P_R, polar air returning northwards ahead of fronts and depressions,

C, continental air from east of 10° E. and south of 50° N. moving westwards towards the British Isles,

D, polar air moving eastwards and southwards near the central region of depressions,

F, air in frontal zones.

To minimize the number of classes, only the trajectory and not the curvature of the path of an air mass has been considered in determining its class. Thus the incidence of P_3 and P_4 together, and not of P_3 and of P_4 separately, was found.

The results for each station are given in Appendix VI ; this shows at each station the monthly percentage frequency and the maximum number of days of occurrence in a month of each class of air as well as the number of years in the 12-year period when the class did not occur.

As the period studied is relatively short and the observations not entirely independent too much importance has not been attributed to small differences in the percentage frequencies of the various months, and conclusions of a general character have not been attempted.

Tropical air and its subdivisions.—During the period considered the incidence of tropical maritime air ($T_1 + T_2$) was least at Stornoway and greatest at Scilly, the annual frequency at Scilly exceeding twice that at Stornoway. Generally, at all three stations, this air occurred more frequently between October and March than at other times of the year. The outstanding frequency in January of 10 days at Kew and 14 days at Scilly occurred in 1944.

Tropical continental air ($T_3 + T_4$) was much less frequent than tropical maritime air, the ratio of the annual frequency of maritime to that of continental being a little less than 2 at Kew and about 4 at Scilly and Stornoway. At Stornoway the incidence of tropical continental air is almost insignificant except in the autumn. At this station the annual frequency was only about one-third that at Kew where the current occurs most often. Here and at Scilly this air is more frequent in spring and autumn than in the other seasons.

Quasi-tropical air, T_Q, was of greater significance at Stornoway than at either Kew or Scilly. At Stornoway this air occurred more frequently in late winter and in spring than did tropical maritime air.

Polar air and its subdivisions.—The annual frequency of polar maritime air (classes P_1, P_2, P_3, P_4, P_5, P_6 and P_7, including that of P_R, polar air returning northwards) outweighed that of the combined frequencies of the tropical, anticyclonic and polar continental classes of air at Stornoway throughout the year and at Kew and Scilly mainly in late spring, summer and early autumn. Polar maritime air accounted for nearly 59 per cent. of all the air masses which occurred at Stornoway during the 12 years as compared with about 42 per cent. of those at Kew and Scilly.

Each of the classes of polar maritime air, except P_7, had an annual frequency which was greater at Stornoway than at Kew or Scilly. At Scilly the annual frequency of P_7 was greatest, that of $P_1 + P_2$ least.

August 1947 was notable for the high frequency of continental air C at Kew and Scilly and for direct polar air at Stornoway, as was also August 1941 for the high frequency of $P_3 + P_4$ at Kew.

There was a distinct preponderance of polar maritime air approaching the British Isles from between north-west and north-east (classes P_1, P_2, P_3 and P_4) over that arriving from between west and south-west (classes P_5, P_6 and P_7) at Kew and Stornoway in midwinter and the spring, and also at Stornoway in the summer and at Scilly in the late spring (May).

Polar continental air ($A_1 + A_2$) was a very rare current. Thus at Kew, in January and February it only appeared on four separate occasions during the 12 years. The relative high percentage frequency was due to the length of the spells of this air (e.g. at Kew, 8 days in January 1940 and 1942, 9 days in February 1942 and 1947).

February 1947 was noteworthy for the absence of all classes of tropical and polar maritime air at Kew ; continental and polar continental air occurred on 20 days.

The combined frequencies of tropical continental, polar continental and anticyclonic (H_{SE}) air show that the drift of air from the continent to the British Isles was least in the summer.

Anticyclonic (indeterminate) air.—The monthly frequency of days with anticyclonic air (classes H) was greatest at Kew and Scilly in September and at Stornoway in May, and was least at all three stations in November.

The annual frequency was greatest at Kew (24 per cent.) and least at Stornoway (14 per cent.), that at Scilly being 22 per cent.

Anticyclonic air moving with an easterly component (classes H_{NE} and H_{SE}) was definitely more frequent than that moving with a westerly component (classes H_{SW} and H_{NW}) in May and from July to October at Kew, in March at Scilly, and in May, August and September at Stornoway.

On 26 days of August 1947, a month noteworthy for abundant sunshine, the air at Kew had come from the continent as classes C, H_{NE}, H_{SE} and T_4.

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APPENDIX I—MEAN AND EXTREME TEMPERATURE AND MEAN VAPOUR PRESSURE, WET-BULB POTENTIAL TEMPERATURE AND DEGREE OF THERMAL STABILITY IN THE UPPER AIR

Pressure	Monthly means of temperature												Summer (July and August)						Winter (January and February)					
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Temperature Mean	Extreme max.	Extreme min.	Mean vapour pressure*	Mean wet-bulb potential temp.	Mean degree of thermal stability†	Temperature Mean	Extreme max.	Extreme min.	Mean vapour pressure*	Mean wet-bulb potential temp.	Mean degree of thermal stability†
mb.	degrees Fahrenheit												° F.	° F.	° F.	mb.	° F.	° F./1,000 ft.	° F.	° F.	° F.	mb.	° F.	° F./1,000 ft.
T_A	(Tropical maritime air in the Azores region)																							
450	−5	−6	−6	−3	0	5	9	10	8	4	1	−3	9	14	6	0·7	65	..	−6	0	−8	0·5	58	..
500	6	3	4	6	9	15	18	19	17	13	10	8	19	24	15	1·2	64	−0·4	5	10	−1	0·8	57	0·0
550	14	12	13	15	17	22	26	27	24	22	19	17	27	32	22	2·1	64	−0·3	13	19	9	1·2	57	−0·1
600	21	20	21	22	25	30	33	35	32	29	27	24	34	38	29	2·8	64	−0·2	21	24	15	1·7	56	−0·2
650	29	27	27	29	32	36	39	41	38	36	34	31	40	45	35	3·8	63	−0·1	28	32	22	2·7	56	−0·1
700	35	34	33	36	39	43	45	47	45	43	40	37	46	50	42	4·9	63	0·0	34	38	29	3·6	56	0·0
750	41	39	39	43	45	48	50	52	50	48	46	43	51	55	47	5·9	62	0·1	40	45	37	4·7	56	0·5
800	45	43	44	48	50	53	54	56	55	52	50	48	55	60	49	8·0	62	0·4	44	50	39	6·1	56	0·8
850	48	47	49	52	54	56	57	59	57	56	54	51	58	63	52	10·5	63	0·8	47	52	44	8·3	56	0·8
900	51	50	52	56	57	58	59	61	60	59	57	53	60	65	55	13·0	63	0·7	50	54	46	10·1	55	0·8
950	55	54	55	57	59	61	62	64	62	61	59	56	63	69	59	15·9	63	0·3	53	58	50	10·6	54	0·2
T_1	(Tropical maritime air with a straight path from south-west of the Azores)																							
450	−9	−11	−11	−8	−5	−1	3	5	3	−1	−4	−7	3	8	−2	1·2	64	..	−10	−5	−13	0·6	57	..
500	1	−1	−1	1	5	9	12	14	12	9	5	2	13	17	9	1·9	64	−0·2	0	5	−4	1·0	57	0·2
550	9	8	7	9	13	17	20	22	20	17	13	11	21	26	17	2·7	64	−0·2	9	13	5	1·5	56	0·2
600	16	16	15	17	20	25	27	30	27	24	20	18	28	32	24	3·6	63	−0·2	16	21	12	2·0	56	0·1
650	23	22	22	23	27	31	34	36	33	30	27	25	35	40	31	4·3	62	−0·1	23	28	19	3·0	55	0·1
700	29	28	28	30	33	37	40	42	39	36	33	31	41	45	37	5·0	61	−0·1	29	34	25	3·9	55	0·2
750	34	34	34	36	39	42	45	47	44	41	39	36	46	50	43	6·2	60	0·1	34	39	28	4·9	54	0·4
500	39	39	39	41	44	47	50	52	49	46	44	41	51	56	47	8·3	61	0·3	39	45	33	6·2	54	0·4
850	42	44	44	45	47	50	54	55	53	50	48	45	54	58	49	11·0	62	0·6	43	49	38	7·7	53	0·8
900	45	47	47	48	51	54	57	58	56	53	51	48	58	61	54	13·5	63	0·9	46	51	40	9·3	53	1·2
950	48	48	49	50	52	57	60	59	58	55	52	49	60	63	57	14·9	61	1·4	48	52	44	10·4	51	2·4
T_2	(Tropical maritime air with an anticyclonic path from south-west of the Azores)																							
450	−7	−7	−8	−5	−1	4	7	9	7	2	−1	−5	8	14	3	1·0	65	..	−8	−4	−10	0·6	58	..
500	4	3	3	5	8	14	16	18	16	12	8	6	17	23	13	1·6	65	−0·3	3	7	0	1·0	57	−0·1
550	13	12	12	13	16	22	24	26	24	22	17	14	25	31	20	2·3	64	−0·2	12	15	8	1·4	57	−0·2
600	20	20	19	21	24	29	31	33	31	27	25	22	32	38	28	3·1	63	−0·2	20	24	16	1·9	56	−0·2
650	27	27	26	28	30	35	38	39	37	34	32	30	39	43	35	3·5	62	−0·1	27	32	22	2·6	56	−0·1
700	33	34	33	35	37	41	44	45	43	40	38	37	44	49	41	4·3	61	0·0	33	37	30	3·3	55	0·0
750	39	39	38	40	42	47	49	50	48	45	43	42	49	53	45	5·5	61	0·3	39	43	35	3·8	54	0·5
800	43	42	43	44	47	51	53	54	51	49	48	46	53	57	48	7·6	61	0·6	43	47	37	4·8	53	0·8
850	46	45	47	48	50	53	55	56	54	52	51	49	55	63	50	9·6	61	1·0	46	51	42	6·1	52	1·7
900	46	46	48	48	52	55	58	58	57	54	52	48	58	69	53	12·0	60	0·8	47	50	43	8·3	51	2·5
950	46	47	47	48	53	59	61	61	59	54	51	48	60	68	56	14·1	60	0·6	47	51	43	9·6	50	3·9
T_3	(Tropical continental air with a straight path from Spain, Mediterranean, north-west Africa or southern Europe in summer)																							
450	−13	−15	−14	−11	−7	0	3	4	1	−3	−7	−10	4	8	0	1·1	64	..	−15	−11	−17	0·5	55	..
500	−3	−5	−3	−1	3	11	13	14	12	8	3	0	14	19	10	1·8	64	−0·2	−5	−1	−7	0·9	55	0·3
550	6	4	6	8	12	20	21	22	20	16	11	9	22	26	19	3·0	64	0·2	4	9	2	1·4	54	0·3
600	13	12	13	15	19	28	29	29	27	23	19	16	30	34	26	4·0	63	−0·4	12	15	9	2·0	54	0·0
650	19	19	20	22	26	35	36	36	34	30	26	23	36	39	32	4·4	63	−0·4	19	22	14	2·8	53	−0·1
700	25	26	27	29	33	42	43	43	40	36	33	30	43	49	40	5·2	62	−0·6	25	30	21	3·8	53	−0·1
750	31	32	33	35	39	48	50	49	45	42	38	35	49	57	46	6·4	62	−0·9	32	36	27	4·7	52	0·2
800	36	37	39	42	46	54	56	56	51	47	43	40	56	65	52	7·6	62	−1·1	36	43	32	5·2	50	0·5
850	40	41	43	47	52	59	61	61	56	53	48	45	61	72	58	10·0	63	−0·9	41	47	35	5·3	48	0·9
900	42	42	47	51	58	64	65	66	61	57	51	46	66	76	60	11·6	64	−0·6	43	48	33	5·5	46	3·5
950	39	42	48	56	62	69	70	70	65	58	52	47	70	81	62	13·1	64	1·2	39	51	29	5·8	40	5·5

* Below the freezing point the vapour pressure is that over ice.
† Positive values indicate stability, negative values instability, for ascending saturated air.

APPENDIX I—*continued*

Pressure	Monthly means of temperature: Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Summer (July and August): Temperature Mean	Summer: Temperature Extreme max.	Summer: Temperature Extreme min.	Summer: Mean vapour pressure*	Summer: Mean wet-bulb potential temp.	Summer: Mean degree of thermal stability†	Winter (January and February): Temperature Mean	Winter: Temperature Extreme max.	Winter: Temperature Extreme min.	Winter: Mean vapour pressure*	Winter: Mean wet-bulb potential temp.	Winter: Mean degree of thermal stability†
mb.	*degrees Fahrenheit*												° F.	° F.	° F.	mb.	° F.	° F./1,000 ft.	° F	° F.	° F.	mb.	° F.	° F./1,000 ft.
T_Q	(Quasi-tropical air from 43–50° N., 15–25° W.)																							
450	−17	−18	−18	−14	−10	−7	−3	−2	−5	−9	−13	−15	−2	3	−8	0·8	61	..	−18	−13	−22	0·4	53	..
500	−6	−7	−7	−3	0	3	7	8	5	2	−2	−4	8	11	2	1·5	61	−0·1	−7	3	−12	0·8	53	0·1
550	2	2	2	6	9	12	16	17	14	10	7	5	16	21	10	2·3	61	−0·1	2	6	−3	1·3	53	0·2
600	11	10	10	14	16	19	23	24	21	18	14	13	23	27	19	3·1	61	−0·2	10	14	5	2·0	52	0·3
650	17	18	17	21	23	26	30	31	28	24	21	19	31	36	26	4·3	61	−0·2	17	21	12	2·6	51	0·2
700	23	24	23	27	30	32	36	38	34	31	27	26	37	42	31	5·0	60	−0·4	24	29	19	3·2	50	0·2
750	30	29	29	32	35	37	43	43	39	36	33	32	43	51	35	6·0	60	−0·1	29	33	23	3·8	49	0·5
800	32	33	34	37	40	43	47	48	44	41	38	36	47	56	38	8·0	61	0·1	33	39	20	4·6	48	1·1
850	35	36	39	41	44	47	51	52	49	44	41	39	52	61	42	9·9	60	0·2	36	42	25	5·5	46	1·4
900	39	38	43	45	48	51	54	55	51	47	44	42	55	69	46	11·7	59	−0·1	38	47	28	6·5	44	1·6
950	40	39	44	48	51	55	59	60	56	50	46	43	59	71	51	13·3	58	0·5	40	50	27	7·3	42	3·4
H_0	(Anticyclonic air)																							
450	−16	−17	−13	−9	−3	1	4	5	3	−2	−8	−13	5	9	1	1·0	64	..	−17	−14	−19	0·3	53	..
500	−5	−6	−3	2	7	11	14	15	13	10	2	−3	14	18	10	1·6	63	−0·2	−6	−2	−8	0·4	53	−0·3
550	4	4	7	11	16	19	22	23	21	18	11	6	23	26	18	2·4	63	−0·2	4	7	1	0·6	53	−0·2
600	11	12	15	19	23	27	29	30	29	26	19	13	29	33	25	3·2	62	−0·1	13	14	8	1·3	53	−0·2
650	18	19	22	25	30	33	35	36	36	33	26	20	36	39	31	3·4	60	0·0	20	24	16	2·3	53	−0·1
700	24	26	28	31	36	40	41	41	42	39	32	27	41	44	36	3·8	58	0·3	26	31	21	2·9	51	0·2
750	30	32	33	36	41	45	46	46	47	43	37	32	46	50	41	3·9	56	0·5	31	37	27	3·0	49	0·5
800	34	36	38	41	44	48	49	50	50	46	40	35	50	56	44	4·4	55	1·2	35	41	31	3·1	46	1·2
850	39	39	40	44	47	51	53	54	53	48	41	37	51	57	46	7·0	56	0·8	38	46	31	3·7	44	2·0
900	39	40	41	46	48	54	57	57	54	48	41	39	56	62	49	9·9	57	−0·5	40	45	32	3·7	41	2·7
950	38	39	42	47	49	58	61	60	56	49	41	38	60	64	53	11·1	57	1·0	39	45	31	5·5	39	4·3
A_1	(Polar continental air with a cyclonic track from north of 50° N. and east of 25° E.)																							
450	−52	−53‡	..	..	..	..	..	..	..	..	−40	−44	..	..	..	..	..	..	−52	−52	−53	..	..	..
500	−42	−43	..	..	..	..	..	..	..	..	−29	−33	..	..	..	..	..	..	−42	−39	−44	0·1	31	0·7
550	−32	−34	−35	..	..	..	..	..	..	..	−19	−24	..	..	..	..	..	..	−32	−30	−35	0·2	31	0·6
600	−23	−25	−26	..	..	..	..	..	..	..	−10	−17	..	..	..	..	..	..	−23	−19	−25	0·4	30	0·4
650	−15	−17	−18	..	..	..	..	..	..	..	−2	−10	..	..	..	..	..	..	−16	−11	−19	0·5	29	0·4
700	−7	−10	−11	..	..	..	..	..	..	..	6	−5	..	..	..	..	..	..	−8	−4	−13	0·7	28	0·5
750	−1	−3	−3	..	..	..	..	..	..	..	12	1	..	..	..	..	..	..	−2	4	−6	0·8	27	0·3
800	5	5	5	..	..	..	..	..	..	..	17	7	..	..	..	..	..	..	5	11	−3	1·5	27	0·3
850	11	10	11	..	..	..	..	..	..	..	23	13	..	..	..	..	..	..	11	21	6	2·0	26	0·2
900	18	16	17	..	..	..	..	..	..	..	29	19	..	..	..	..	..	..	17	27	13	2·7	27	−0·4
950	23	21	24	..	..	..	..	..	..	..	34	23	..	..	..	..	..	..	22	29	17	3·5	27	0·0
A_2	(Polar continental air with an anticyclonic track from north of 50° N. and east of 25° E.)																							
450	−45	−46	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	−46	−44	−49	..	..	..
500	−35	−38	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	−36	−34	−42	..	..	..
550	−25	−28	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	−26	−23	−32	0·3	..	..
600	−15	−18	..	..	..	..	..	..	..	..	..	.	..	..	..	..	..	..	−17	−12	−23	0·5	32	.
650	−8	−9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	−9	−5	−19	0·7	32	0·9
700	−2	−3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	−3	−1	−6	0·8	31	1·0
750	3	3	..	..	..	..	..	..	..	..	11	6	..	..	..	..	..	..	3	7	−2	1·0	30	1·2
800	8	8	12	..	..	..	..	..	..	..	17	12	..	..	..	..	..	..	8	12	4	1·6	29	0·8
850	15	14	19	..	..	..	..	..	..	..	23	18	..	..	..	..	..	..	14	18	9	2·1	27	0·3
900	19	19	23	..	..	..	..	..	..	..	26	23	..	..	..	..	..	..	19	25	11	3·1	28	−0·4
950	23	24	28	..	..	..	..	..	..	..	34	27	..	..	..	..	.	..	24	31	14	4·1	29	0·2

* Below the freezing point the vapour pressure is that over ice.
† Positive values indicate stability, negative values instability, for ascending saturated air.
‡ Estimated value.

APPENDIX I—*continued*

Pressure	Monthly means of temperature: Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Summer (July and August): Temperature Mean	Extreme max.	Extreme min.	Mean vapour pressure*	Mean wet-bulb potential temp.	Mean degree of thermal stability†	Winter (January and February): Temperature Mean	Extreme max.	Extreme min.	Mean vapour pressure*	Mean wet-bulb potential temp.	Mean degree of thermal stability†
mb.	degrees Fahrenheit												°F.	°F.	°F.	mb.	°F.	°F./1,000 ft.	°F.	°F.	°F.	mb.	°F.	°F./1,000 ft.
P_{Ic} (Polar maritime air in the Icelandic region)																								
450	−55	−56	−54	−50	−46	−38	−30	−30	−36	−45	−51	−54	−29	−28	−32	0·1	46	..	−55	−52	−58	..	..	..
500	−46	−47	−44	−39	−36	−28	−20	−19	−26	−34	−41	−43	−19	−18	−22	0·3	45	0·5	−45	−43	−51	..	..	1·0
550	−37	−38	−35	−31	−27	−19	−11	−10	−18	−25	−32	−33	−10	−9	−12	0·6	45	0·5	−36	−32	−43	0·1	27	1·0
600	−29	−29	−28	−23	−19	−12	−2	−2	−11	−18	−23	−25	−1	0	−6	0·9	44	0·4	−28	−23	−36	0·2	26	1·1
650	−21	−22	−22	−16	−11	−5	6	5	−4	−11	−16	−18	6	8	2	1·5	43	0·6	−21	−17	−30	0·3	24	1·3
700	−15	−15	−15	−10	−5	2	11	9	2	−4	−9	−11	11	14	6	1·9	42	1·0	−14	−7	−22	0·5	23	1·2
750	−10	−9	−8	−4	1	8	17	15	8	3	−2	−5	17	22	12	2·4	41	0·9	−8	0	−19	0·7	21	1·2
800	−4	−2	−1	2	8	14	23	20	13	9	4	1	21	26	18	3·4	40	0·2	−3	6	−16	1·0	20	1·0
850	2	2	5	9	14	20	28	26	19	15	10	7	28	32	24	4·4	40	−0·6	3	13	−12	1·2	19	0·4
900	8	9	11	15	20	26	35	31	25	21	16	13	33	38	26	5·5	41	−0·7	8	19	−4	1·5	18	−0·1
950	14	15	17	20	26	33	41	37	32	27	22	19	39	44	35	7·3	42	−0·8	14	26	2	2·1	17	−0·5
P_1 (Polar maritime air with a cyclonic track from north and north-east of Iceland)																								
450	−50	−51	−49	−43	−39	−30	−24	−26	−30	−38	−44	−48	−24	−20	−30	0·2	50	..	−49	−46	−55	..	..	..
500	−40	−41	−38	−32	−28	−19	−13	−15	−19	−27	−33	−37	−14	−10	−18	0·5	49	0·4	−39	−35	−43	0·1	33	0·8
550	−30	−30	−28	−22	−18	−9	−4	−5	−10	−17	−23	−27	−4	−2	−9	0·9	48	0·3	−29	−26	−33	0·2	32	0·7
600	−21	−21	−19	−14	−9	−1	5	3	−1	−8	−14	−18	4	7	0	1·4	47	0·1	−20	−16	−23	0·3	31	0·5
650	−12	−12	−10	−6	−1	6	12	11	7	0	−6	−9	12	15	8	1·9	47	0·1	−11	−9	−17	0·5	31	0·4
700	−4	−5	−3	2	6	13	19	17	13	7	2	−1	19	22	14	2·8	47	0·1	−4	1	−10	0·8	30	0·3
750	3	3	5	9	12	20	25	24	19	13	9	6	25	30	19	3·8	47	0·2	3	7	−4	1·1	30	0·2
800	9	9	11	15	18	25	31	29	25	20	16	12	30	37	25	4·8	46	0·2	10	13	2	1·6	30	0·0
850	16	15	17	21	24	31	36	35	32	26	22	19	35	42	30	5·9	47	−0·2	16	21	7	2·3	30	0·0
900	22	21	23	28	30	36	42	41	37	32	28	25	41	49	35	7·4	48	−0·4	21	26	13	3·2	29	−0·1
950	26	27	29	33	36	42	47	46	43	38	34	30	47	53	40	8·6	48	−0·5	27	32	18	3·9	30	−0·5
P_2 (Polar maritime air with an anticyclonic track from north and north-east of Iceland)																								
450	−46	−47	−42	−39	−34	−26	−20	−22	−28	−32	−36	−40	−23	−18	−26	0·1	49	..	−46	−42	−48	..	..	..
500	−35	−37	−32	−28	−24	−16	−9	−12	−17	−21	−26	−30	−13	−7	−15	0·3	48	0·4	−35	−31	−39	0·1	34	0·8
550	−25	−27	−23	−19	−15	−7	0	−3	−8	−13	−16	−21	−3	2	−5	0·7	48	0·3	−26	−21	−30	0·3	33	0·6
600	−17	−18	−15	−11	−7	1	9	5	0	−5	−8	−12	6	10	4	1·2	47	0·2	−16	−14	−22	0·5	33	0·5
650	−9	−9	−7	−3	1	9	16	12	8	3	−1	−5	13	17	11	1·8	47	0·3	−8	−6	−14	0·7	33	0·4
700	−1	−1	1	4	9	14	22	19	15	10	6	2	19	23	17	2·5	47	0·1	0	2	−5	1·0	32	0·6
750	6	5	7	10	15	19	27	25	21	16	13	9	25	28	23	3·1	46	0·0	5	8	2	1·3	32	0·7
800	12	10	13	16	20	25	32	30	27	23	19	15	30	34	28	4·5	46	−0·1	11	15	8	1·7	31	0·5
850	17	16	19	22	26	31	36	35	33	28	24	20	36	39	31	5·3	47	−0·2	17	21	11	2·5	31	0·2
900	22	22	25	27	31	37	43	41	38	33	29	25	41	45	38	7·6	47	−0·6	22	27	14	3·4	30	0·3
950	27	27	30	33	36	42	47	46	43	39	35	31	46	49	44	8·8	48	−0·1	27	33	18	3·9	29	1·2
P_3 (Polar maritime air with a cyclonic track from north-west of Iceland, approaching the British Isles from the north-west)																								
450	−43	−45	−42	−39	−34	−27	−22	−22	−26	−31	−36	−40	−22	−19	−26	0·3	51	..	−44	−41	−47	0·1	38	..
500	−32	−33	−30	−27	−23	−16	−11	−12	−15	−20	−25	−28	−11	−8	−15	0·6	50	0·3	−32	−28	−38	0·2	38	0·6
550	−21	−23	−20	−17	−13	−7	−1	−2	−6	−11	−15	−18	−1	1	−6	1·0	50	0·2	−21	−18	−27	0·4	37	0·5
600	−12	−13	−11	−9	−5	1	7	6	3	−3	−7	−10	7	9	3	1·5	49	0·2	−12	−9	−17	0·6	37	0·4
650	−4	−5	−3	−1	3	9	15	14	11	5	1	−1	14	17	11	2·2	49	0·1	−4	0	−9	0·9	37	0·3
700	4	3	5	7	10	17	22	21	18	13	9	6	21	26	18	3·0	49	0·0	3	7	0	1·3	37	0·2
750	11	11	12	14	17	23	28	27	24	19	15	13	27	31	23	4·1	49	−0·1	10	14	5	1·7	36	0·1
800	17	17	18	20	23	28	33	32	30	25	22	20	32	37	28	5·3	49	−0·2	17	21	11	2·5	36	−0·4
850	23	23	24	26	29	33	39	38	35	31	27	25	39	44	35	6·7	50	−0·7	23	26	16	3·3	36	−0·2
900	29	29	30	31	35	39	45	44	41	37	33	31	44	50	41	8·2	51	−0·9	28	33	23	4·5	37	−0·1
950	33	34	35	36	40	45	50	49	46	42	38	35	50	53	46	10·1	52	−0·1	34	38	29	5·3	36	0·4

* Below the freezing point the vapour pressure is that over ice.
† Positive values indicate stability, negative values instability, for ascending saturated air.

APPENDIX I—*continued*

Pressure	Monthly means of temperature: Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Summer (July and August): Temperature Mean	Extreme max.	Extreme min.	Mean vapour pressure*	Mean wet-bulb potential temp.	Mean degree of thermal stability†	Winter (January and February): Temperature Mean	Extreme max.	Extreme min.	Mean vapour pressure*	Mean wet-bulb potential temp.	Mean degree of thermal stability†
mb.	degrees Fahrenheit												° F.	° F.	° F.	mb.	° F.	° F./1,000 ft.	° F.	° F.	° F.	mb.	° F.	° F./1,000 ft.
P4	(Polar maritime air with an anticyclonic track from north-west of Iceland, approaching the British Isles from the north-west)																							
450	−36	−37	−35	−31	−25	−21	−15	−17	−21	−27	−31	−35	−16	−14	−18	0·5	54	..	−36	−33	−40	0·1	41	..
500	−26	−26	−24	−20	−15	−10	−4	−7	−11	−16	−20	−24	−4	−2	−9	0·9	54	0·3	−25	−23	−30	0·2	40	0·9
550	−16	−17	−15	−11	−5	−1	4	2	−2	−8	−11	−15	5	7	0	1·2	53	0·2	−16	−12	−20	0·4	39	0·9
600	−8	−9	−7	−3	2	6	12	10	5	1	−3	−7	12	15	8	1·7	53	0·3	−9	−3	−12	0·6	38	0·9
650	0	−2	1	5	9	13	19	17	12	8	4	1	18	21	14	2·5	52	0·4	−2	3	−6	1·0	37	0·8
700	6	5	7	11	16	20	25	23	18	14	10	8	24	27	20	3·3	51	0·3	5	10	−1	1·4	37	0·6
750	12	11	13	17	22	26	30	28	25	20	17	15	29	33	25	4·2	50	0·3	11	15	6	1·8	37	0·2
800	18	17	19	22	28	31	35	33	30	25	22	20	33	38	29	5·2	49	0·2	17	22	11	2·6	37	0·1
850	24	22	24	28	33	37	41	38	36	31	28	26	40	44	36	6·7	50	−0·5	23	27	17	3·4	36	−0·1
900	29	28	30	33	39	42	46	45	41	37	33	31	46	49	42	8·2	51	−0·7	29	34	23	4·5	37	0·2
950	33	33	35	39	43	47	51	50	47	41	38	36	49	53	47	9·8	52	−0·2	34	39	27	5·6	36	1·3
P5	(Polar maritime air with a cyclonic track from north-west of Iceland, approaching the British Isles from the west)																							
450	−37	−37	−35	−32	−28	−23	−18	−19	−22	−26	−30	−34	−18	−16	−21	0·5	52	..	−37	−32	−41	0·1	42	..
500	−26	−26	−24	−21	−17	−12	−7	−8	−11	−15	−19	−23	−8	−5	−9	0·8	52	0·0	−26	−22	−29	0·3	41	0·5
550	−16	−16	−15	−12	−8	−3	2	1	−2	−6	−10	−13	2	4	0	1·3	52	−0·1	−16	−11	−22	0·4	41	0·4
600	−7	−7	−6	−3	0	5	11	10	7	2	−2	−5	10	13	8	1·8	52	−0·1	−8	−4	−12	0·7	40	0·5
650	0	1	2	5	8	13	18	17	14	10	7	4	18	22	15	2·5	52	0·0	1	4	−4	1·0	40	0·3
700	8	8	10	13	16	20	25	24	21	18	14	10	25	28	31	3·6	51	0·0	8	12	4	1·5	40	0·1
750	14	15	16	19	22	26	31	30	27	24	20	17	30	33	26	4·5	51	−0·1	14	18	11	2·3	39	−0·1
800	21	21	22	25	28	32	37	35	33	30	26	24	36	39	32	5·9	51	−0·3	21	25	18	3·1	39	−0·3
850	27	27	28	31	34	38	43	41	39	35	32	29	42	45	38	7·3	52	−0·7	27	32	24	4·3	40	−0·3
900	33	33	34	37	39	43	48	47	44	41	37	35	48	51	45	9·1	53	−0·6	33	37	29	5·1	40	−0·1
950	37	37	39	41	43	48	53	52	50	46	42	39	52	54	49	11·0	54	−0·3	37	42	33	6·2	39	0·3
P6	(Polar maritime air with an anticyclonic track from north-west of Iceland, approaching the British Isles from the west)																							
450	−31	−31	−30	−27	−21	−17	−13	−13	−18	−23	−26	−29	−13	−10	−15	0·5	55	..	−31	−26	−35	0·1	44	..
500	−20	−21	−20	−16	−11	−7	−2	−3	−8	−13	−16	−18	−2	0	−5	0·9	55	0·1	−21	−16	−25	0·3	43	0·8
550	−11	−12	−11	−7	−2	2	7	7	1	−4	−7	−9	8	10	4	1·4	55	0·1	−12	−8	−15	0·4	42	0·7
600	−3	−4	−3	1	6	10	15	14	10	4	1	−2	16	17	12	2·1	55	0·2	−4	−2	−8	0·7	41	0·5
650	3	4	5	9	14	18	22	21	17	12	8	6	22	23	18	2·8	54	0·3	3	6	1	1·0	41	0·4
700	10	11	12	15	20	24	28	26	23	18	15	12	27	30	25	4·0	53	0·3	10	14	8	1·6	40	0·3
750	16	16	18	21	26	30	33	31	29	24	21	19	32	36	29	4·6	52	0·2	16	20	13	2·1	40	0·4
800	22	22	24	27	32	35	39	37	35	30	27	24	38	41	34	5·6	52	−0·2	22	27	17	3·0	39	0·5
850	27	27	29	32	37	40	45	43	40	35	32	29	43	48	39	7·3	53	−0·5	28	31	24	4·0	39	−0·2
900	32	33	34	37	42	46	51	49	45	40	37	35	49	53	47	9·4	53	−0·5	33	37	30	5·1	39	0·1
950	37	38	39	42	47	51	56	54	50	45	41	39	54	57	50	11·7	54	0·0	36	41	32	6·0	38	0·8
P7	(Polar maritime air with a cyclonic track from north-west of Iceland, approaching the British Isles from south of 45° N.)																							
450	−28	−29	−29	−26	−21	−17	−14	−13	−16	−19	−23	−26	−13	−11	−16	0·6	56	..	−28	−22	−33	0·3	47	..
500	−17	−18	−17	−14	−10	−6	−2	−1	−4	−8	−11	−15	−2	1	−4	1·0	56	−0·3	−17	−12	−21	0·5	47	0·3
550	−8	−9	−8	−5	−1	3	7	7	5	1	−2	−5	8	10	5	1·6	56	−0·2	−7	−2	−13	0·8	47	0·2
600	1	0	1	4	8	12	15	16	14	10	7	4	16	19	12	2·2	56	−0·2	2	6	−4	1·1	47	0·1
650	9	8	9	12	15	19	22	23	21	17	15	12	23	26	20	2·9	56	−0·1	10	12	5	1·7	46	0·1
700	16	15	16	19	22	26	29	29	28	24	22	19	29	32	26	4·3	55	0·1	16	20	12	2·4	46	0·3
750	23	22	22	25	28	32	35	36	34	31	27	25	35	39	31	5·2	55	−0·1	22	27	17	3·0	45	0·2
800	29	28	27	31	34	38	40	42	40	36	33	31	40	45	38	6·6	55	−0·3	27	33	24	4·2	45	0·0
850	34	33	33	37	39	43	46	47	45	42	39	37	46	50	43	8·7	56	−0·5	33	39	30	5·4	45	−0·2
900	39	39	39	42	45	48	51	52	50	47	44	42	51	54	49	11·0	57	−0·7	39	44	35	7·1	46	−0·3
950	44	43	44	47	50	54	57	56	55	52	49	46	56	59	51	12·9	57	−0·4	44	48	41	8·4	46	−0·2

* Below the freezing point the vapour pressure is that over ice.
† Positive values indicate stability, negative values instability, for ascending saturated air.

APPENDIX 11—AVERAGE LAPSE RATE OF TEMPERATURE IN SUMMER AND WINTER

Height (Km.)	Height (ft.)	T_A	T_1	T_2	T_3	T_Q	H_0	Air mass A_1	Air mass A_2	P_{IC}	P_1	P_2	P_3'	P_4	P_5	P_6	P_7
		degrees Fahrenheit per 1,000 ft.*															
		SUMMER															
5–6	16,400–19,700	3·4	3·6	3·2	3·7	3·7	3·4	..	..	4·1	4·2	4·2	4·2	4·1	4·3	4·1	4·3
4–5	13,100–16,400	3·3	3·3	3·1	3·4	3·5	3·1	..	..	3·8	3·9	3·9	3·9	3·6	4·0	3·6	3·8
3–4	9,800–13,100	2·8	3·0	3·0	3·3	3·1	2·7	..	..	3·4	3·7	3·4	3·7	3·1	3·7	3·0	3·4
2–3	6,600– 9,800	2·6	2·7	2·3	3·4	2·9	2·3	..	..	3·0	3·3	3·3	3·3	2·9	3·3	3·0	3·3
1–2	3,300– 6,600	1·5	2·0	1·7	3·3	2·4	2·2	..	..	3·7	3·5	3·4	3·6	3·3	3·5	3·5	3·4
0·5–1	1,650– 3,300	1·9	1·7	1·9	2·7	2·4	2·5	..	..	4·0	4·1	3·7	4·1	3·5	3·8	3·4	3·7
		WINTER															
5–6	16,400–19,700	3·6	3·7	3·8	3·8	4·2	4·0	..	..	4·3	4·4	4·4	4·5	4·2	4·5	4·3	4·4
4–5	13,100–16,400	3·4	3·4	3·5	3·6	3·8	3·8	..	..	4·1	4·3	4·2	4·4	3·8	4·3	4·1	4·1
3–4	9,800–13,100	3·3	3·2	3·2	3·4	3·4	3·4	4·4	3·8	3·8	4·2	4·1	4·2	3·7	4·1	3·8	3·6
2–3	6,600– 9,800	2·7	2·7	2·5	3·0	2·6	2·6	4·2	3·3	3·5	4·0	3·7	4·0	3·7	4·0	3·4	3·3
1–2	3,300– 6,600	2·0	2·4	1·4	1·8	1·8	0·7	3·9	3·6	3·8	3·9	3·6	3·9	3·6	3·8	3·2	3·5
0·5–1	1,650– 3,300	2·2	1·3	0·3	−1·6	1·0	−0·9	3·4	2·6	4·0	3·8	3·0	3·6	3·2	3·4	2·3	3·3

* The lapse rate is positive when temperature diminishes with increasing height.

APPENDIX III—AVERAGE AND EXTREME DAILY MAXIMUM AND MINIMUM TEMPERATURE NEAR THE SURFACE AT KEW FOR EACH MONTH

degrees Fahrenheit

Air mass	January			February			March			April			May			June		
	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest
DAILY MAXIMUM TEMPERATURES																		
T_1	53	56	50	53	55	50	57	60	54	59	61	57	67	71	62	70	75	68
T_2	52	56	50	55	58	50	58	63	55	65	70	61	72	75	69	74	77	71
T_3	49	53	43	50	55	46	59	66	52	68	76	56	76	87	67	78	87	68
T_Q	48	51	42	49	51	44	52	55	48	55	58	53	61	66	58	67	75	63
H_0	41	47	33	46	55	35	55	68	42	62	73	50	68	80	53	75	86	68
H_{NE}	37	41	31	37	44	33	46	50	40	52	61	45	60	68	49	70	77	60
H_{SE}	41	49	35	45	55	38	53	59	48	64	73	59	70	79	63	79	86	74
H_{SW}	49	52	47	52	56	49	57	62	53	62	67	59	67	69	65	71	76	67
H_{NW}	41	46	38	44	49	41	50	53	47	61	65	58	65	68	61	72	80	65
A_1	31	34	28	34	40	30	39	46	32	43	44	41	..	..	..	..	..	..
A_2	32	36	27	34	39	31	39	45	31	47	48	45	..	..	..	..	..	..
P_1	36	39	32	38	41	32	41	46	37	47	51	41	52	58	46	59	62	53
P_2	35	39	29	39	41	36	44	48	39	50	53	47	54	57	50	61	66	58
P_3	41	44	39	44	48	42	47	49	45	53	58	51	57	60	54	63	67	59
P_4	41	44	38	43	47	39	49	53	44	55	59	49	60	66	54	66	74	61
P_5	46	49	44	47	48	43	51	54	49	57	61	54	62	63	59	65	68	60
P_6	48	51	44	49	54	45	52	57	47	61	70	56	67	74	61	71	78	63
P_7	50	53	48	51	54	48	54	57	52	59	65	54	65	68	63	69	71	64
M*	44	..	..	45	..	..	49	..	..	55	..	..	62	..	..	68	..	..
DAILY MINIMUM TEMPERATURES																		
T_1	49	51	47	48	51	46	49	52	46	51	55	49	53	57	51	58	63	54
T_2	46	53	41	47	52	43	48	51	43	50	55	45	54	57	48	58	62	54
T_3	40	47	36	40	44	38	44	51	39	49	53	45	55	63	50	59	65	53
T_Q	42	47	38	40	46	34	44	48	39	46	49	41	48	53	44	55	56	52
H_0	29	35	21	30	39	23	34	41	24	38	49	31	44	52	33	51	59	44
H_{NE}	29	39	23	30	34	23	34	41	26	39	46	31	44	51	35	51	58	44
H_{SE}	33	38	27	32	39	28	36	41	31	44	49	38	48	55	44	55	60	49
H_{SW}	42	45	41	43	43	40	43	47	41	47	50	43	50	52	47	55	60	49
H_{NW}	33	39	29	34	38	30	37	41	34	42	48	38	45	50	40	52	58	45
A_1	25	30	19	28	32	24	32	37	25	37	39	33	..	..	..	..	..	..
A_2	25	30	18	27	30	21	29	35	19	32	35	31	..	..	..	..	..	..
P_1	31	35	27	31	35	27	34	39	31	37	41	32	41	46	35	48	53	44
P_2	25	30	18	28	29	24	30	34	26	36	39	31	38	41	30	46	50	42
P_3	34	36	32	36	39	32	37	38	34	42	46	38	46	49	41	51	53	47
P_4	33	41	27	34	39	28	36	41	31	41	43	35	44	50	39	51	57	46
P_5	38	42	35	38	41	35	41	43	37	46	50	43	49	53	46	53	56	49
P_6	37	40	34	37	41	34	41	45	36	44	48	41	48	53	44	52	59	48
P_7	44	46	40	43	45	41	44	46	41	47	51	44	51	53	49	55	58	54
M*	35	..	..	35	..	..	36	..	..	40	..	..	45	..	..	51	..	..

Air mass	July			August			September			October			November			December		
	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest
DAILY MAXIMUM TEMPERATURES																		
T_1	72	76	67	72	77	67	70	72	67	62	67	59	57	61	54	54	59	52
T_2	76	78	74	76	78	72	71	75	65	62	65	59	57	61	55	53	55	51
T_3	82	91	72	82	92	74	74	81	67	64	71	58	57	66	53	52	55	49
T_Q	68	71	63	68	71	63	65	71	62	58	62	52	53	58	49	50	53	45
H_0	78	85	72	73	82	65	68	79	60	56	66	47	43	52	39	38	45	30
H_{NE}	72	79	65	72	77	64	65	72	57	54	61	47	49	56	43	40	43	33
H_{SE}	80	85	77	80	84	75	71	79	65	58	63	52	49	55	43	42	49	36
H_{SW}	76	80	74	75	79	71	70	73	64	59	63	54	51	55	48	49	51	47
H_{NW}	75	79	71	74	77	69	66	74	57	57	61	51	47	52	43	42	45	39
A_1	..	..	..	..	..	..	..	..	..	..	..	..	41	41	40	34	39	27
A_2	..	..	..	..	..	..	..	..	..	..	..	..	41	42	39	36	40	29
P_1	64	66	58	62	64	57	57	61	53	47	53	43	43	48	40	40	44	36
P_2	67	70	65	65	68	61	59	64	55	47	49	45	43	46	37	36	42	31
P_3	66	68	63	66	68	63	61	67	59	51	54	47	48	51	46	44	47	42
P_4	69	74	66	69	72	64	62	68	55	54	60	48	47	51	41	43	48	36
P_5	69	72	67	69	72	66	65	68	61	56	58	53	51	53	48	49	51	47
P_6	74	83	69	76	82	68	69	76	63	59	65	55	53	56	49	49	54	44
P_7	72	75	69	70	74	64	69	73	63	59	63	56	54	56	52	52	54	49
M*	71	..	..	70	..	..	65	..	..	56	..	..	49	..	..	45	..	..
DAILY MINIMUM TEMPERATURES																		
T_1	60	63	57	60	64	57	59	61	56	55	61	51	53	58	49	50	53	47
T_2	60	63	57	61	64	57	58	62	53	52	55	49	49	54	46	46	49	41
T_3	61	66	54	61	66	55	58	64	48	51	57	45	48	53	45	45	48	40
T_Q	57	61	56	57	60	56	55	59	50	50	55	45	45	49	41	43	47	39
H_0	54	61	49	51	57	43	46	54	40	37	48	28	32	39	25	29	39	33
H_{NE}	56	60	52	57	61	51	53	58	43	44	52	33	39	48	30	33	41	27
H_{SE}	57	61	53	56	61	53	52	59	45	43	51	36	40	44	34	34	42	26
H_{SW}	59	63	56	59	62	53	57	61	53	52	56	49	47	49	44	45	47	43
H_{NW}	57	61	52	54	57	50	52	56	46	41	47	36	36	43	30	34	37	30
A_1	..	..	..	..	..	..	..	..	..	..	..	..	37	39	35	27	31	21
A_2	..	..	..	..	..	..	..	..	..	..	..	..	37	38	34	29	34	23
P_1	53	57	48	52	55	45	47	54	43	36	39	33	34	41	30	33	38	29
P_2	49	52	46	49	53	44	44	49	38	35	39	29	30	33	25	26	32	19
P_3	54	58	48	54	58	48	52	57	46	42	48	37	39	43	35	36	39	33
P_4	53	58	48	51	57	47	48	54	42	41	47	36	37	43	29	33	39	27
P_5	57	59	53	56	60	52	54	58	49	46	50	42	43	47	39	41	44	37
P_6	56	62	53	56	62	50	52	58	46	46	48	40	42	47	37	40	45	35
P_7	59	62	57	58	61	57	56	59	54	49	53	43	46	50	44	45	49	41
M*	55	..	..	54	..	..	50	..	..	43	..	..	39	..	..	36	..	..

* M=all air masses combined, 1871-1940

APPENDIX IV—AVERAGE DAILY MEAN AND EXTREME DAILY MAXIMUM AND MINIMUM TEMPERATURE NEAR THE SURFACE AT KEW IN SUMMER AND WINTER

Daily temperature	T_1	T_2	T_3	T_4	T_Q	H_0	H_{NE}	H_{SE}	H_{SW}	H_{NW}	A_1	A_2	P_1	P_2	P_3	P_4	P_5	P_6	P_7	All air masses combined 1931–45	All air masses combined 1871–1940
	degrees Fahrenheit																				
SUMMER																					
Average	66	68	70	72	63	64	64	68	67	65	..	..	57	57	60	60	63	65	65	63	62
Extreme maximum	71	76	79	85	68	75	72	80	76	75	..	..	62	66	66	68	69	75	71	71	71
Extreme minimum	60	60	61	60	57	52	56	57	59	55	..	..	52	49	54	52	56	55	59	56	54
WINTER																					
Average	51	50	47	43	45	36	33	37	46	38	29	30	34	31	39	38	42	43	47	40	40
Extreme maximum	53	53	50	49	48	43	37	43	50	42	33	33	37	36	42	42	47	48	50	44	44
Extreme minimum	49	47	44	38	41	29	29	32	43	34	26	26	31	26	35	34	38	37	43	35	35

APPENDIX V—AVERAGE DAILY MEAN AND EXTREME DAILY MAXIMUM AND MINIMUM VAPOUR PRESSURE* NEAR THE SURFACE AT KEW IN SUMMER AND WINTER

Daily vapour pressure	T_1	T_2	T_3	T_4	T_Q	H_0	H_{NE}	H_{SE}	H_{SW}	H_{NW}	A_1	A_2	P_1	P_2	P_3	P_4	P_5	P_6	P_7	All air masses combined, 1886–1915
	millibars																			
SUMMER																				
Average	17·1	17·4	18·0	18·1	14·7	14·1	11·8	15·1	16·9	13·6	..	..	11·4	11·2	13·4	13·2	14·9	15·0	15·6	13·7
Extreme maximum	20·1	19·8	21·7	22·2	16·2	17·6	14·8	17·3	19·4	15·5	..	..	13·1	13·1	15·3	14·6	17·5	16·8	17·7	
Extreme minimum	15·4	15·5	14·2	14·9	12·4	10·7	10·9	12·6	13·8	11·6	..	..	9·5	9·4	11·4	11·9	12·8	13·3	13·7	
WINTER																				
Average	10·9	10·3	9·6	8·6	8·9	7·0	5·1	6·2	8·4	6·4	4·1	3·9	4·9	4·7	6·3	6·3	7·6	7·7	9·2	6·8
Extreme maximum	12·4	12·0	11·1	10·4	10·5	9·1	6·0	7·8	9·8	7·8	5·3	5·0	5·8	6·0	7·5	7·4	8·9	9·4	10·6	
Extreme minimum	9·4	8·3	7·6	6·7	7·3	5·5	4·0	4·8	6·9	5·1	2·7	3·0	3·9	3·0	5·4	5·3	6·3	6·2	7·9	

* Computed from the daily mean temperature and mean relative humidity.

APPENDIX VI—INCIDENCE OF DIFFERENT AIR MASSES AT THE SURFACE AT KEW, SCILLY AND STORNOWAY

Air mass	January Frequency (%)	January Max. no. of days (days)	January Years with no occurrence (yr.)	February Frequency (%)	February Max. no. of days (days)	February Years with no occurrence (yr.)	March Frequency (%)	March Max. no. of days (days)	March Years with no occurrence (yr.)	April Frequency (%)	April Max. no. of days (days)	April Years with no occurrence (yr.)	May Frequency (%)	May Max. no. of days (days)	May Years with no occurrence (yr.)	June Frequency (%)	June Max. no. of days (days)	June Years with no occurrence (yr.)
KEW																		
T_1+T_2	9	10	2	10	7	2	8	6	1	4	5	3	4	5	6	8	6	1
T_3+T_4	3	4	7	4	3	7	5	4	6	5	4	6	6	5	3	3	3	7
T_Q	2	5	9	3	4	8	4	4	5	2	2	6	2	3	8	1	3	9
H_0	2	3	8	3	2	6	7	6	2	4	4	5	2	3	6	4	5	5
H_{NE}	2	3	9	2	3	8	5	5	6	4	3	4	5	7	5	8	8	2
H_{SE}	5	9	6	6	5	3	7	11	6	7	5	2	5	4	2	5	4	4
H_{SW}	4	8	7	5	5	6	6	6	3	6	4	2	3	3	7	7	7	1
H_{NW}	2	2	7	3	4	5	6	5	3	10	16	1	4	3	5	6	5	4
A_1+A_2	7	8	8	6	9	8	1	2	11	0	0	12	0	0	12	0	0	12
C*	11	10	3	10	11	5	11	7	3	5	6	6	13	10	2	3	3	7
P_1+P_2	7	7	4	6	6	5	7	9	5	7	6	3	14	12	2	6	7	6
P_3+P_4	13	10	3	10	8	3	8	9	3	11	9	3	8	7	3	13	10	1
P_5+P_6	7	6	3	14	9	4	8	6	2	14	8	0	9	6	1	19	10	0
P_7	4	7	6	2	1	6	3	5	7	3	4	8	4	3	5	1	1	7
P_R*	10	8	1	8	9	3	4	6	5	5	4	4	10	6	0	5	3	2
F*	8	10 (F* and D*)	2 (F* and D*)	6	5 (F* and D*)	2 (F* and D*)	7	8 (F* and D*)	1 (F* and D*)	11	7 (F* and D*)	0 (F* and D*)	8	7 (F* and D*)	1 (F* and D*)	8	8 (F* and D*)	2 (F* and D*)
D*	4			2			3			2			3			3		
SCILLY																		
T_1+T_2	13	14	2	16	6	2	10	7	1	7	6	2	6	5	1	10	6	0
T_3+T_4	2	3	8	2	3	8	4	6	5	3	3	6	2	4	8	1	2	10
T_Q	4	8	7	4	6	6	3	4	6	2	2	5	2	2	9	1	2	9
H_0	1	2	10	2	3	6	6	5	2	3	2	6	3	4	5	4	4	6
H_{NE}	1	1	7	2	3	9	7	6	4	8	10	4	5	4	5	7	6	2
H_{SE}	4	5	7	5	5	2	7	5	3	6	5	3	4	5	5	4	3	4
H_{SW}	4	6	6	4	4	7	5	9	6	5	3	1	3	3	6	6	6	1
H_{NW}	1	2	8	2	3	9	5	4	4	8	7	2	5	5	4	8	5	0
A_1+A_2	3	6	9	6	8	8	0·3	1	11	0	0	12	0	0	12	0	0	12
C*	9	8	3	11	8	5	9	9	5	6	6	5	10	6	1	3	4	7
P_1+P_2	4	6	7	3	3	6	3	4	7	4	4	4	11	12	4	4	4	5
P_3+P_4	11	8	1	10	7	3	5	5	4	11	9	1	11	8	2	14	9	1
P_5+P_6	18	10	0	15	7	1	13	6	0	17	9	0	14	8	0	20	8	0
P_7	9	10	2	3	2	4	6	7	4	4	5	6	3	4	6	2	3	8
P_R*	7	5	4	3	3	6	6	4	3	5	3	2	6	5	3	3	2	5
F*	7	9 (F* and D*)	0 (F* and D*)	10	9 (F* and D*)	0 (F* and D*)	8	8 (F* and D*)	1 (F* and D*)	8	6 (F* and D*)	0 (F* and D*)	9	8 (F* and D*)	0 (F* and D*)	11	9 (F* and D*)	0 (F* and D*)
D*	2			2			3			3			6			2		

Air mass	July Frequency (%)	July Max. no. of days (days)	July Years with no occurrence (yr.)	August Frequency (%)	August Max. no. of days (days)	August Years with no occurrence (yr.)	September Frequency (%)	September Max. no. of days (days)	September Years with no occurrence (yr.)	October Frequency (%)	October Max. no. of days (days)	October Years with no occurrence (yr.)	November Frequency (%)	November Max. no. of days (days)	November Years with no occurrence (yr.)	December Frequency (%)	December Max. no. of days (days)	December Years with no occurrence (yr.)
KEW																		
T_1+T_2	8	4	0	6	4	2	6	4	4	6	5	2	10	9	2	8	7	1
T_3+T_4	4	3	3	5	5	5	3	3	5	9	6	1	7	7	6	2	2	6
T_Q	3	5	7	1	1	8	1	1	8	2	3	7	2	2	8	4	8	5
H_0	2	4	6	4	4	7	3	3	5	4	6	5	2	2	7	5	5	3
H_{NE}	5	6	3	6	12	6	9	7	3	6	5	2	0·3	1	11	3	4	6
H_{SE}	8	8	1	6	5	3	9	5	2	7	6	2	7	8	3	6	6	2
H_{SW}	6	7	3	5	4	4	7	5	2	4	3	4	4	5	4	4	4	1
H_{NW}	2	2	6	3	2	3	7	7	3	4	3	4	4	9	7	4	3	5
A_1+A_2	0	0	12	0	0	12	0	0	12	0	0	12	0	0	12	3	6	9
C*	2	2	8	7	14	6	3	4	7	14	10	3	8	9	5	7	8	2
P_1+P_2	5	5	7	5	6	4	6	7	4	4	2	3	6	7	4	5	4	5
P_3+P_4	15	8	0	13	13	1	11	10	2	5	6	5	12	8	1	10	7	0
P_5+P_6	18	9	0	18	10	0	14	7	0	16	11	0	16	10	1	14	7	0
P_7	2	2	7	1	2	8	2	3	7	4	4	5	5	5	5	7	7	5
P_R*	8	8	2	7	4	2	6	6	4	6	5	2	5	4	2	7	6	2
F*	8	8 (F* and D*)	0 (F* and D*)	9	10 (F* and D*)	2 (F* and D*)	9	9 (F* and D*)	0 (F* and D*)	5	6 (F* and D*)	4 (F* and D*)	7	8 (F* and D*)	1 (F* and D*)	8	6 (F* and D*)	1 (F* and D*)
D*	4			4			4			4			5			3		
SCILLY																		
T_1+T_2	13	6	0	10	8	1	7	7	2	9	5	2	17	12	2	14	10	1
T_3+T_4	1	1	9	2	3	9	3	3	6	5	4	4	6	10	6	1	5	9
T_Q	2	3	9	1	2	9	2	2	9	3	3	6	2	2	7	4	6	5
H_0	1	2	8	4	4	6	4	4	5	3	4	6	2	3	9	4	7	6
H_{NE}	5	6	6	4	5	6	7	7	5	3	4	5	2	7	9	5	5	5
H_{SE}	4	3	4	4	3	7	7	7	2	7	8	4	4	4	7	4	4	4
H_{SW}	5	6	4	2	3	9	6	5	3	5	4	3	3	3	5	4	4	3
H_{NW}	5	4	4	5	7	5	10	7	2	3	2	4	3	5	7	5	5	4
A_1+A_2	0	0	12	0	0	12	0	0	12	0	0	12	0	0	12	2	5	2
C*	2	2	9	5	11	8	2	3	9	11	8	4	6	6	5	5	7	7
P_1+P_2	3	4	7	6	8	6	4	4	5	2	2	8	5	6	7	1	2	9
P_3+P_4	17	8	0	13	4	1	11	9	2	6	7	5	7	5	1	9	6	1
P_5+P_6	21	12	0	21	12	0	14	9	0	20	12	0	22	12	0	20	12	0
P_7	2	2	6	2	3	9	5	4	4	5	7	6	3	3	6	6	7	6
P_R*	6	4	1	8	5	0	6	4	4	8	8	2	6	6	3	5	3	2
F*	7	7 (F* and D*)	1 (F* and D*)	8	10 (F* and D*)	0 (F* and D*)	9	5 (F* and D*)	0 (F* and D*)	5	4 (F* and D*)	0 (F* and D*)	6	7 (F* and D*)	1 (F* and D*)	9	5 (F* and D*)	0 (F* and D*)
D*	6			5			3			5			6			2		

* For the meaning of these symbols, C, P_R, F and D see p. 23.

APPENDIX VI—*continued*

Air mass	January Frequency	January Max. no. of days	January Years with no occurrence	February Frequency	February Max. no. of days	February Years with no occurrence	March Frequency	March Max. no. of days	March Years with no occurrence	April Frequency	April Max. no. of days	April Years with no occurrence	May Frequency	May Max. no. of days	May Years with no occurrence	June Frequency	June Max. no. of days	June Years with no occurrence
	%	days	yr.	%	days	yr.	%	days	yr.	%	days	yr.	%	days	yr.	%	days	yr.
STORNOWAY																		
T_1+T_2	4	6	4	4	4	6	6	6	5	5	3	5	1	1	10	5	7	3
T_3+T_4	0	0	12	0·6	2	11	2	3	8	2	4	10	1	1	9	0·3	1	11
T_Q	2	4	9	6	6	5	7	6	5	6	6	4	4	4	3	1	2	8
H_0	3	4	7	1	4	10	1	2	10	2	3	7	2	3	8	5	6	5
H_{NE}	1	1	10	3	4	8	1	2	9	2	2	8	5	3	2	3	5	7
H_{SE}	4	6	8	4	5	6	6	4	2	4	4	5	5	5	3	4	5	6
H_{SW}	2	2	7	2	2	6	5	4	4	5	6	4	3	5	7	3	4	6
H_{NW}	1	2	9	0·6	1	10	2	1	5	3	5	6	4	5	5	3	3	8
A_1+A_2	1	2	9	5	11	9	1	3	11	0	0	12	0	0	12	0	0	12
C*	6	5	3	7	11	7	10	7	4	5	5	5	6	6	4	2	5	10
P_1+P_2	13	9	3	8	5	2	10	8	4	13	12	4	16	12	1	14	11	1
P_3+P_4	15	10	2	13	9	3	8	7	1	15	12	2	8	5	1	13	7	0
P_5+P_6	16	10	2	17	10	1	19	10	1	16	9	0	15	10	0	19	10	0
P_7	5	7	6	5	7	7	3	3	6	3	4	7	3	3	7	1	3	9
P_R*	17	10	0	15	8	1	9	7	2	8	6	0	12	6	0	13	6	0
F*	6	8 (F and D together)	1 (F and D together)	7	5 (F and D together)	0 (F and D together)	7	10 (F and D together)	1 (F and D together)	8	5 (F and D together)	0 (F and D together)	7	8 (F and D together)	0 (F and D together)	8	9 (F and D together)	1 (F and D together)
D*	4			2			3			3			8			6		

Air mass	July Frequency	July Max. no. of days	July Years with no occurrence	August Frequency	August Max. no. of days	August Years with no occurrence	September Frequency	September Max. no. of days	September Years with no occurrence	October Frequency	October Max. no. of days	October Years with no occurrence	November Frequency	November Max. no. of days	November Years with no occurrence	December Frequency	December Max. no. of days	December Years with no occurrence
	%	days	yr.	%	days	yr.	%	days	yr.	%	days	yr.	%	days	yr.	%	days	yr.
STORNOWAY																		
T_1+T_2	3	2	5	5	4	4	4	4	4	7	6	3	9	6	0	6	5	3
T_3+T_4	1	2	9	0	0	12	1	3	11	3	3	5	3	5	7	1	1	10
T_Q	3	3	7	1	1	9	3	2	5	4	3	6	4	3	5	4	5	5
H_0	1	3	11	2	2	5	4	8	7	3	3	7	2	3	7	2	4	7
H_{NE}	2	6	10	2	3	7	1	1	9	2	4	9	0·3	1	11	0·3	1	11
H_{SE}	3	6	7	6	9	4	6	8	4	6	5	5	2	3	7	3	4	7
H_{SW}	4	6	7	3	4	7	2	2	8	4	6	5	2	2	7	5	5	6
H_{NW}	0·3	1	11	2	2	6	2	4	7	2	3	6	1	2	10	2	2	9
A_1+A_2	0	0	12	0	0	12	0	0	12	0	0	12	0	0	12	1	3	11
C*	1	2	9	4	5	6	4	6	7	6	8	6	6	9	6	4	4	4
P_1+P_2	12	7	2	16	12	0	9	10	1	7	7	3	12	9	2	5	5	5
P_3+P_4	14	8	0	12	6	0	20	13	0	11	9	1	14	8	0	14	9	0
P_5+P_6	21	10	0	19	14	0	21	14	0	20	16	0	17	8	0	21	12	0
P_7	1	1	9	1	1	10	4	3	5	3	4	7	4	3	4	5	7	5
P_R*	14	8	0	13	7	0	11	8	1	13	9	1	12	8	0	17	10	0
F*	7	11 (F and D together)	1 (F and D together)	8	8 (F and D together)	0 (F and D together)	3	5 (F and D together)	0 (F and D together)	6	7 (F and D together)	2 (F and D together)	7	10 (F and D together)	0 (F and D together)	5	7 (F and D together)	1 (F and D together)
D*	13			6			5			3			5			5		

* For the meaning of these symbols C, P_R, F and D, see p. 23.