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THE FREQUENCY OF FOG IN THE LONDON AREA COMPARED WITH THAT IN RURAL AREAS OF EAST ANGLIA AND SOUTH-EAST ENGLAND

By H. C. SHELLARD, B.Sc.

Introduction.—A few years ago a special analysis of observations of visibility in the ranges below 440 yards was made in co-operation with the Statistical Research Unit of the London School of Hygiene and Tropical Medicine. The data were required for an investigation into relationships between mortality from respiratory diseases and the weather. They included numbers of hours in each week with visibility less than 44 yards, less than 220 yards and less than 440 yards at Kingsway, based on three-hourly observations, and at Croydon, Mildenhall and West Raynham, based on hourly observations, the period covered being October 1946 to March 1954. Subsequently similar data were obtained to complete the 10-year period to September 1956.

The purpose of this paper is to present and discuss the 10-year frequencies for the four stations, to show that a good estimate can be obtained of the overall hourly frequencies using data for the four hours 0300, 0900, 1500 and 2100 G.M.T. only and thus to obtain estimated fog frequencies for other stations in south-east England covering the same period.

Discussion.—Table I gives the average number of hours per year with visibility in various fog ranges at Mildenhall, West Raynham and Croydon for the period October 1946 to September 1956, based on hourly observations. Similar frequencies are given for Kingsway based on three-hourly observations, on the assumption that on the average a report of fog at any one of these hours represents three hours of fog in the same range; it could of course represent anything from one to five hours in any particular case.

TABLE I—FOG FREQUENCIES AT FOUR STATIONS, OCTOBER 1946–SEPTEMBER 1956

	Visibility		
	<44 yd	44–210 yd	220–430 yd
	average number of hours per annum		
Mildenhall	20	135	63
West Raynham	17	184	75
Croydon	21	76	82
Kingsway	19	107	103

Two interesting features of this table are that the frequencies of dense fog are about the same at all four stations and that, contrary to popular belief, the frequencies of visibilities less than 220 yards are greater in rural areas of East Anglia than they are in the London area, so far as it is represented by Croydon and Kingsway. In the 220–430-yard range the frequencies are greater at the London stations.

Monthly and annual frequencies of fog at the hours 0300, 0900, 1500 and 2100 G.M.T. have been published in Table IV of the *Monthly Weather Report* and its Annual Summary since 1945. It was decided to assemble the published frequencies for Mildenhall, West Raynham and Croydon for the period October 1946 to September 1956 so that they could be compared with those given in Table I, which are based on hourly observations. The results are shown in Table II, the frequencies having been multiplied by six to give estimates of the average numbers of hours per annum in the various ranges. It should be mentioned that owing to a change in the visibility reporting code from 1 January 1949 the published frequencies for the period October 1946 to December 1948 actually related to the ranges <55 yards, 55–210 yards, 220–540 yards and 550–1,090 yards. It is not considered, however, that this will appreciably affect the 10-year frequencies, except perhaps to make those for the 220–430-yard range a little higher and those in the 440–1,090-yard range a little lower than they should be.

TABLE II—ESTIMATED FOG FREQUENCIES AT THREE STATIONS, OCTOBER 1946–SEPTEMBER 1956, BASED ON OBSERVATIONS AT 0300, 0900, 1500 AND 2100 G.M.T.

	Visibility			
	<44 yd	44–210 yd	220–430 yd	440–1,090 yd
		average number of hours per annum		
Mildenhall	14	139	62	238
West Raynham	13	176	75	227
Croydon	23	75	80	281

Comparison of the figures in the first three columns of Table II with the corresponding frequencies in Table I shows that very satisfactory estimates of annual fog frequency can be obtained using the observations made at 0300, 0900, 1500 and 2100 G.M.T.

Making use of this result, annual fog frequencies have been estimated from the figures published in the *Monthly Weather Report* for as many inland stations as possible in south-east England. In order to make the work easier and to include two stations for which observations were not available for 1946, the 10-year period January 1947 to December 1956 has been used. The results are given in Table III.

The figures for Kingsway (for which data are not published in the *Monthly Weather Report*) given in the first three columns of Table III have been taken from Table I and those in the last column have been estimated from the 1941–46 data published by Marshall.[1] In the case of Kew Observatory observations are not available for 0300 G.M.T. but estimates of the 0300 G.M.T. frequencies were obtained by multiplying the 0900 values by the ratio between the frequencies at 0300 and 0900 for Croydon Airport.

Some interesting conclusions can be drawn from Table III. The last column shows that fog, defined as visibility less than 1,100 yards, is more frequent in central London than in the suburbs or in rural areas and that it is rather more frequent in outer London, as represented by Kew Observatory and London Airport, than in the country. It is also apparent that Tangmere, only a few miles from the south coast, is by far the most fog-free of all the stations considered.

TABLE III—ESTIMATED FOG FREQUENCIES AT TWELVE STATIONS IN SOUTH-EAST ENGLAND, BASED ON OBSERVATIONS AT 0300, 0900, 1500 AND 2100 G.M.T. DURING THE PERIOD 1947–56 INCLUSIVE

	Visibility			
	<44 yd	<220 yd	<440 yd	<1,100 yd
	average number of hours per annum			
Kingsway	19	126	230	940
Croydon	25	104	187	462
Kew Observatory	79	213	365	633
London Airport	46	209	304	562
West Malling	27	181	267	524
Tangmere	5	51	86	233
South Farnborough	28	159	265	540
Boscombe Down	5	164	261	430
Abingdon	16	174	248	455
Cranfield	39	206	292	544
Mildenhall	14	159	220	459
West Raynham	12	196	273	505

Visibilities below 440 yards are by far the most frequent in outer London, values in central London being somewhat less than at most rural stations. Croydon is an exception here and this is probably due to its greater altitude (201 feet). Visibilities below 220 yards, and these are perhaps of special interest in that they cause most disruption of surface transport, also tend to be most frequent in outer London, but all the rural stations, except Tangmere, have a greater frequency than either Kingsway or Croydon. The frequencies of dense fogs at Kingsway are comparable with those at such rural stations as Mildenhall, West Raynham and Abingdon, and are much lower than those at Kew Observatory and London Airport. Tangmere and Boscombe Down are notably free from dense fogs. The London Airport figures in Table III may be compared with those given by N. E. Davis,[2] for the four-year period August 1946 to July 1950, from which the following annual frequencies have been obtained:

Visibility		
<220 yd	<440 yd	<1,100 yd
annual frequencies in hours		
228	311	673

The agreement is reasonably good, having regard to the shorter period used.

It may perhaps also be concluded from Table III that frequencies of visibility below 1,100 yards are more likely to be of value in air-pollution studies than those of visibilities in the lower ranges.

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SNOW IN RELATION TO CERTAIN SYNOPTIC PARAMETERS

By R. MURRAY, M.A.

Introduction.—In an earlier paper[1] some statistics were presented of the frequency of occurrence of snow and rain at low-lying stations (that is, altitudes below 300 feet) over the British Isles in relation to various parameters. The frequencies of snow and rain associated with the simultaneous occurrence of two or more of the parameters were not then investigated. The original data have since been re-examined with a view to assessing the probability of the precipitation being in the form of snow when certain pairs of contemporaneous parameters are known. The 1000–500-millibar thickness and the surface temperature form one pair; the freezing level and the surface temperature form another.

It should be noted that Lamb[2] has also related type of precipitation to the 1000–500-millibar thickness, but his classification of the types of precipitation was slightly different from Murray's as was pointed out in a discussion[3] at the Royal Meteorological Society.

Treatment of data.

(*a*) 1000–500-*millibar thickness and surface temperature.*

The occurrences of snow (including snow showers), sleet (including sleet showers) and rain (including rain showers and drizzle) were grouped in a double-entry table according to the values of the prevailing 1000–500-millibar thickness (class-interval 50 geopotential feet) and surface temperature (class-interval 1°F). The relatively infrequent cases of hail were excluded. The number of observations in each elementary compartment was rather variable and sometimes quite small so the basic data were smoothed in the following way. If the number of snow occurrences in an elementary compartment of the double-entry table is S_{pq}, where the suffixes pq are position indicators, then S_{pq} was replaced by the value $\sum_{p-1,q-1}^{p+1,q+1} S_{pq}$, that is, by the sum of the original S_{pq} and the eight surrounding values. This procedure was carried out for all values of p and q. The same procedure was adopted for the sleet and rain cases. The derived occurrences were then converted into percentage frequencies. Isopleths of the 90, 50 and 10 per cent frequencies of occurrence of snow were sketched in with only a little freehand smoothing; these isopleths are shown as the thick lines in Figure 1. The 90, 50 and 10 per cent frequencies of occurrence of snow and sleet are also shown as thin lines in Figure 1. The lines are broken in the more doubtful places where only a small number of observations was available.

(*b*) *Freezing level and surface temperature.*

The occurrences of snow, sleet and rain were also classified in relation to the altitude of the freezing level (class-interval 500 feet) and surface temperature (class-interval 1°F). A smoothing technique similar to that employed for the 1000–500-millibar thickness and surface temperature classification was used. The smoothing procedure could not be applied without modification to the occurrences of precipitation in the lowest class-interval for freezing level (that is, freezing level less than 500 feet). In this case the frequency of snow, S_{p1}, was

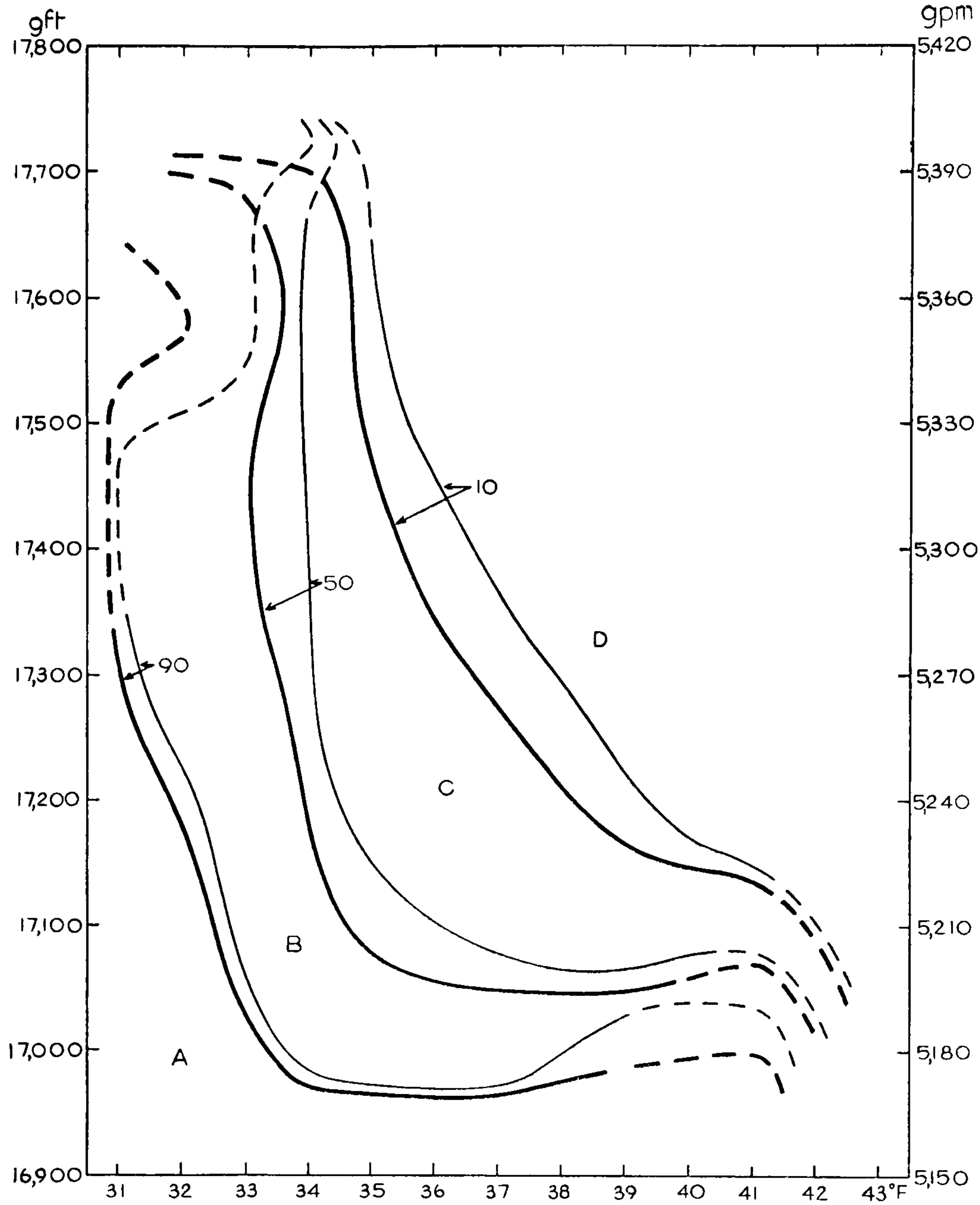

FIGURE I—PERCENTAGE PROBABILITY (P) OF TYPE OF PRECIPITATION IN RELATION TO SURFACE TEMPERATURE AND 1000–500-MB. THICKNESS

Pairs of lines indicate 90, 50 and 10 per cent probabilities of snow, and snow and sleet. Thick lines: snow; thin lines: snow and sleet. Region A is $P > 90$, B is $90 > P > 50$, C is $50 > P > 10$ and D is $P < 10$.

replaced by $\sum_{p-1}^{p+1} S_{p1}$, that is, by the sum of the original S_{p1} and the two adjacent values. Percentage frequencies were then computed from the derived occurrences. Isopleths of the 90, 50 and 10 per cent frequencies of occurrence of snow (thick lines) and snow together with sleet (thin lines) are shown in Figure 2.

Discussion.—The thick lines (probability of snow) and the thin lines (probability of snow or sleet) in Figures 1 and 2 are not greatly different in position for the same percentage values. This merely shows that sleet is generally a good deal less likely than either snow or rain.

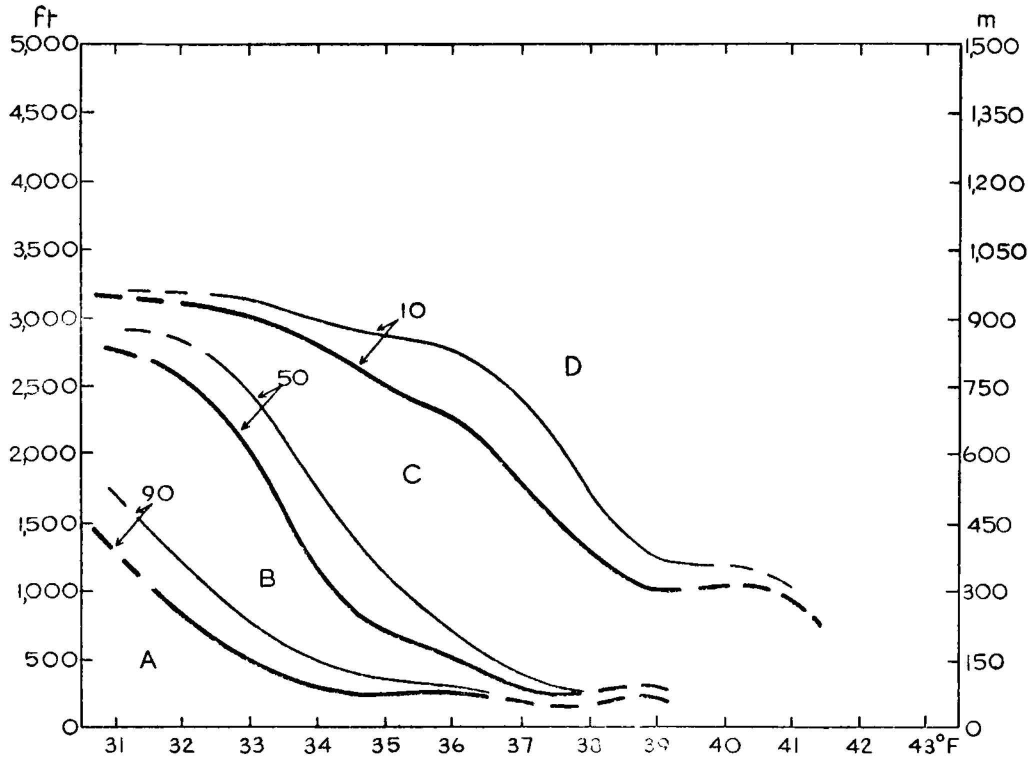

FIGURE 2—PERCENTAGE PROBABILITY (P) OF TYPE OF PRECIPITATION IN RELATION TO SURFACE TEMPERATURE AND FREEZING LEVEL

Pairs of lines indicate 90, 50 and 10 per cent probabilities of snow, and snow and sleet. Thick lines: snow; thin lines: snow and sleet. Region A is P > 90, B is 90 > P > 50, C is 50 > P > 10 and D is P < 10.

From Figure 1 it is evident, not surprisingly, that the probability of snow is high when both thickness and surface temperature are low, and it is low when both thickness and surface temperature are high. However, the snow probability tends to be relatively high when either thickness or surface temperature is relatively high. Owing to the smallness of the sample of data there is some doubt about the precise position of the lines in the top left and bottom right parts of Figure 1, but the general trend of the lines is approximately correct.

It will be noted that with thickness equal to about 17,000 geopotential feet (5,180 geopotential metres) as surface temperature increases the probability of snow slowly decreases, then it increases to near 100 per cent with surface temperature about 40°F. Such a thickness associated with a surface temperature about 40°F is rather uncommon; it occurs occasionally when very unstable maritime polar air has been advected abnormally far south over the warm Atlantic. The instability snowfall under these conditions generally occurs on windward coasts. Snow may continue over land, of course, where the surface temperature generally falls (assuming that the thickness remains at about the same low level).

A contrasting situation arises when thickness is high relative to surface temperature. For instance, when surface temperature is near 32°F as thickness increases the snow probability slowly decreases, then it appears to increase to greater than 90 per cent with thickness equal to about 17,600 geopotential feet (5,360 geopotential metres). The variation of snow probability with thickness for surface temperature 33°F and 34°F is in the same sense as for surface temperature equal to 32°F. When snow occurs with surface temperature less than 35°F and thickness greater than 17,500 geopotential feet (5,330 geopotential metres), the air mass is always stable. Such a situation often arises when an Atlantic warm front is responsible for the precipitation. The warm tropospheric air generally overruns the cold surface air; the trajectory of the air near the surface may be from the cold continent, or perhaps cold surface air is relatively stagnant during or after a frosty night.

The snow probability lines for various combinations of surface temperature and altitude of the freezing level are shown in Figure 2 and no comment seems necessary.

Figures 1 and 2 might prove helpful in forecasting practice. Figure 1, in particular, seems suitable for practical use since both surface temperature and 1000–500-millibar thickness are well established synoptic parameters. Typical forecasts made with the aid of Figure 1 might be as follows:

Region A—snow probable,
Region B—snow probable with sleet or rain in places (or at times),
Region C—rain probable with sleet or snow in places (or at times),
Region D—rain probable.

(If the snow probability is about 50 per cent (± 10 per cent, say,) it might sometimes be advisable to forecast "rain or snow".)

Of the two parameters employed in Figure 1, surface temperature is likely to be the more difficult to forecast with adequate accuracy. It must be estimated after assessing the effects of temperature advection, the trajectory of the air in relation to the thermal conditions of the under-lying surface (for example, sea, land, snow cover), diurnal heating and cooling, turbulence, cooling by precipitation and so on. There is generally a complex interaction between the various factors. The effect of precipitation on temperature is occasionally very important and most difficult to allow for, especially as it cannot be isolated from other effects. Lumb[4] and Gold[5] in unpublished memoranda have made estimates of the cooling effect of melting snow falling through the lowest layers of the atmosphere. The cooling of the lowest layers may be very considerable with heavy and prolonged precipitation, especially if the air is relatively dry initially, and the surface temperature may fall by more than 10°F over land areas. In such cases precipitation at the ground may start as rain and turn to snow; the snowfall may well be substantial if in addition there is little advection or cold advection.

In view of the complexity of the problem, it is not to be expected that Figure 1 will be of much use in short-period prediction when the forecaster must clearly depend on his scientific diagnosis of the meteorological situation. However, over longer periods, when detailed forecasting of the form of the precipitation is often impossible, it is thought that Figure 1 may prove useful as a general guide. The forecaster who is aware of the possibilities and factors involved can then generally word his forecast to cover the risks and uncertainties of the situation.

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A NOTE ON THE EFFECT OF RADIATION ERRORS ON THE MEASUREMENTS OF TEMPERATURE INVERSIONS BY RADIO-SONDE

By R. FRITH, M.A., Ph.D.

Temperatures measured by radio-sonde are subject to radiation errors when the sonde is exposed to sunshine (see Scrase[1]). Consequently whenever a sonde, during its ascent, emerges from cloud and into sunshine it will begin to indicate too high a temperature. Because of the lag of the instrument it takes something like 30 seconds, say 500 feet, for this increase to be recorded in full. Thus the recorded temperature lapse over this 500 feet will be reduced by the amount of the radiation error. If, as is often the case, there is an inversion above the cloud, then this inversion will tend to be recorded stronger than it really is. If there is no inversion there then the sonde will record either a reduced lapse, or an isothermal layer, or perhaps even an inversion—depending upon the relative magnitudes of the radiation error and the lapse rate above the cloud. The magnitude of the radiation error depends upon the elevation of the sun, the height of the sonde and the nature of the surface (in this case cloud) below the sonde; but it will usually be rather more than 1°F at 750 millibars and rather more than 2°F at 500 millibars. Therefore, when a sonde emerges from cloud, with clear sky above, one would expect differences between day and night ascents as follows in Table I:

TABLE I—RECORDED TEMPERATURE LAPSE IN THE FIRST 500 FEET ABOVE CLOUD TOP

Night	Day	
	Cloud top at 750 mb	*Cloud top at 500 mb*
Inversion	Stronger inversion	Stronger inversion
Isothermal	Weak inversion	Inversion
1°F. lapse	Isothermal	Weak inversion
Lapse > 1°F.	Lapse or isothermal	Lapse or isothermal

Thus temperature inversions indicated by radio-sondes should tend to be stronger and more frequent by day than by night. The difference should be greater in summer than in winter and greater at southern than at northern stations; and it should be greater at high levels than at low levels not only because the radiation error increases with height but also because the sky above a cloud top is more likely to be clear when the cloud top is high.

An attempt has been made to assess the magnitude of this effect by examining the relative frequencies with which inversions of various intensities have been reported by day and by night from British radio-sonde stations. Table II shows the number of inversions reported during the six summer months in the three-year period 1949–51 at five radio-sonde stations, when the base of the inversion was (*a*) in the layer 700–800 millibars; (*b*) in the layer 600–700 millibars; (*c*) in the layer 400–600 millibars.

TABLE II—FREQUENCY OF INVERSIONS REPORTED DURING THE SIX SUMMER MONTHS IN THE THREE-YEAR PERIOD 1949–51, BY DAY (0900+1500 G.M.T.) AND BY NIGHT (0300+2100 G.M.T.)

	Intensity of inversion °F.	Number of inversions reported with base in the layer 700–800 mb Night	700–800 mb Day	600–700 mb Night	600–700 mb Day	400–600 mb Night	400–600 mb Day
	⩾ 1	129	148	72	80	61	65
	⩾ 2	70	80	31	33	26	27
Lerwick	⩾ 3	39	44	13	13	14	7
	⩾ 4	21	20	7	4	6	4
	⩾ 5	10	10	4	3	3	2
	⩾ 1	216	225	100	113	85	91
	⩾ 2	133	149	53	54	37	29
Aldergrove	⩾ 3	67	88	18	28	6	11
	⩾ 4	34	53	10	16	1	7
	⩾ 5	23	35	8	6	1	1
	⩾ 1	220	234	89	109	63	110
	⩾ 2	141	152	47	42	20	41
Downham Market	⩾ 3	79	87	20	14	5	19
	⩾ 4	46	49	5	6	3	8
	⩾ 5	34	26	4	2	3	5
	⩾ 1	214	252	82	100	72	106
	⩾ 2	143	171	39	40	32	50
Larkhill	⩾ 3	79	100	18	16	12	19
	⩾ 4	48	58	15	11	4	9
	⩾ 5	29	39	7	4	1	3
	⩾ 1	173	193	86	93	75	94
	⩾ 2	114	102	43	41	35	41
Camborne	⩾ 3	67	54	17	14	9	16
	⩾ 4	47	42	6	6	5	9
	⩾ 5	24	24	1	2	1	4

Total number of ascents about 1,115 by day and the same number by night at each station.

TABLE III—FREQUENCIES OF INVERSIONS REPORTED DURING THE SIX SUMMER MONTHS IN THE THREE-YEAR PERIOD 1949–51, BY DAY (0900+1500 G.M.T.) AND BY NIGHT (0300+2100 G.M.T.)

	Intensity of inversion °F.	Number of inversions reported with base in the layer 700–800 mb Night	700–800 mb Day	600–700 mb Night	600–700 mb Day	400–600 mb Night	400–600 mb Day
	⩾ 1	345 (10)	373 (11)	172 (8)	193 (8)	146 (7)	156 (7)
	⩾ 2	203 (8)	229 (8)	84 (5)	87 (5)	63 (5)	56 (4)
Lerwick, Aldergrove	⩾ 3	106 (6)	132 (6)	31 (3)	41 (4)	20 (2)	18 (2)
	⩾ 4	55 (4)	73 (5)	17 (2)	18 (2)	7 (2)	11 (2)
	⩾ 5	33 (3)	45 (4)	12 (2)	9 (2)	4 (1)	3 (1)
	⩾ 1	607 (13)	679 (14)	257 (9)	302 (10)	210 (8)	310 (10)
	⩾ 2	398 (11)	425 (11)	129 (7)	123 (7)	87 (5)	132 (7)
Larkhill, Downham	⩾ 3	225 (8)	241 (9)	55 (4)	44 (4)	26 (3)	54 (4)
Market, Camborne	⩾ 4	141 (7)	149 (7)	26 (3)	23 (3)	12 (2)	26 (3)
	⩾ 5	87 (5)	89 (5)	12 (2)	8 (2)	5 (1)	12 (2)

Figures in brackets are approximate "probable errors" of the frequencies.

It is apparent that at the higher levels at the three southern stations (Downham Market, Larkhill and Camborne) there are far more inversions reported by day than by night. In Table III these three southern stations, and the two northern stations, have been grouped together.

In Table III the figures in brackets are approximate "probable errors", and are equal to $0{\cdot}6\ \sqrt{N.p.q}$, where N is the total number of ascents; p is the "probability" of an inversion being found with base in the layer specified; and $q = 1 - p$. Since there is some correlation between consecutive observations and since, very occasionally, there is more than one inversion with base in the specified layer, this "probable error" must be regarded as no more than an indication of the sort of accuracy of the frequencies found. However, it is abundantly clear that the greater number of inversions found at the higher levels by day at the southern stations is significant. It is less easy to establish that the difference is due to the radiation error. It has already been shown that the strength of any inversion 500 feet deep, with base in the 400–600-millibar layer, will, if the inversion occurs at the top of a sheet of cloud with clear sky above, be recorded some 2°F stronger by day than by night. From Table III we see that there were seven reported inversions, at night, with a temperature rise of 4°F; and 14 with a temperature rise of 3°F. Moreover, an examination of the records showed that none of these 21 inversions were reported as less than 500 feet deep. Therefore, any which occurred at a cloud top with no cloud above would have been recorded as, by day, 5°F or stronger, inversions. Thus the difference between the day and night frequencies in the number of inversions of 5°F or more would be explained if seven of these 21 inversions occurred at a cloud top with no cloud above.

A similar analysis was made of the relative day and night frequencies of less intense inversions. The number of inversions reported was adjusted to exclude all inversions less than 500 feet deep (from an examination of the records) and from these adjusted figures an estimate was made of the number of isothermal layers which were at least 500 feet deep (no attempt was made to estimate the number of layers with a lapse rate of 1°F per 500 feet, although such layers could also give rise to a reported inversion by day). It was found that the day–night differences would be completely explained in all cases if something like one inversion (or isothermal layer) in three occurred at a cloud top with no cloud above. This does not seem unreasonable.

Table III shows that this day–night difference is not significant, at any level, at the northern stations; and that at lower levels at the southern stations it is only significant for weak inversions. Table IV shows the total number of reported inversions, by day and by night, during the six winter months.

TABLE IV—FREQUENCIES OF INVERSIONS REPORTED DURING THE SIX WINTER MONTHS IN THE THREE-YEAR PERIOD 1949–51, BY DAY (0900+1500 G.M.T.) AND BY NIGHT (0300+2100 G.M.T.)

	Number of inversions reported with base in the layer					
	700–800 mb		600–700 mb		400–600 mb	
	Night	Day	Night	Day	Night	Day
Lerwick, Aldergrove ...	363 (10)	346 (10)	197 (8)	185 (8)	171 (8)	190 (8)
Larkhill, Downham Market, Camborne	603 (13)	590 (13)	284 (10)	301 (10)	246 (9)	298 (10)

Figures in brackets are approximate "probable errors" of the frequencies.

It will be seen that the only difference which appears to be significant is that at the highest level at the southern stations, where the day frequency is some 20 per cent greater than the night frequency.

Summary.—We find that, during the summer months at the southern stations, there are about 50 per cent more inversions, with bases in the layer 400–600 millibars, reported by day than by night. This difference falls to 20 per cent for inversions with bases in the layer 600–700 millibars. No statistically significant difference is found at lower levels still. During the winter months the difference at 600–700 millibars becomes insignificant and the difference in the 400–600-millibar level falls to about 20 per cent. No significant difference is found at the northern stations, winter or summer, at any level. These differences are probably wholly due to radiation errors of the sonde.

(Note: Since 1956 radiation corrections have been applied to British radiosonde measurements; but since these corrections are applied whether the sonde is in sunshine or not (indeed, in the troposphere, it is not usually possible to know whether the sonde is in sunshine or not) the application of these corrections will make no difference to the effects studied in this note.)

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CONDITIONS IN A SOUTH-EASTERLY AIRFLOW OVER SOUTHERN EAST ANGLIA

By P. S. GRIFFITHS

The contribution by J. E. Atkins[1] indicating by the use of fitness figures a tendency for the occurrence of poor flying conditions at Stradishall more frequently with winds from the south-east than from other directions was read with considerable interest at Stansted where a similar effect has been noted from time to time. An analysis of the type made at Stradishall has not been made but individual occurrences have been investigated, one of which is quoted, and as a result of this work, surface winds from the south-east quadrant are considered to be prone to deteriorations of cloud base and visibility more severe than those from other directions. In winds from directions other than the south-east quadrant, broad agreement is found between Stansted and stations in the surrounding area in comparison of the height of cloud base and visibility after due allowance has been made for relative heights above sea level in the case of cloud base and of proximity to and orientation from smoke sources in the case of visibility. But with south-easterly winds, this broad similarity is not found on occasions when the airstream in the first 1,000 to 2,000 feet is saturated or very nearly so, as is normally the case in fog, below stratus and near fronts. The reasons suggested for this are firstly that the lower airflow is affected by a slow ascent up the East Anglian Ridge, even though it appears that such lifting in this area is so slight as might be thought negligible and secondly that there is an appreciable smoke source in the lower Thames basin, significantly to the east of the main smoke source of the London Metropolitan area.

It may be that the poor flying conditions indicated by the analysis at Stradishall are similarly due to either or both of these reasons in view of the similarity of position and exposure of the two stations. The sketch map (Figure 1) indicates the topography of the area, from which it may be seen that the north-eastward extension of the Chiltern Hills into East Anglia rises to a height of around 800 feet on the western border of Hertfordshire but falls progressively north-eastwards. There is an area of ground 13 miles to the north-west of Stansted with a maximum elevation of 520 feet, just south of Royston, but to the north and north-east of Stansted the highest ground is at or a little under 400 feet and this extends to Stradishall, thereafter lowering still further. The terrain maintains the general features of the Chiltern Ridge, of a gradual rise from south-east to north-west, with a scarp slope on the north-west face of the ridge. The rise of ground on the south-east facing slope in the Stansted area is so slight as to be inappreciable to the casual observer.

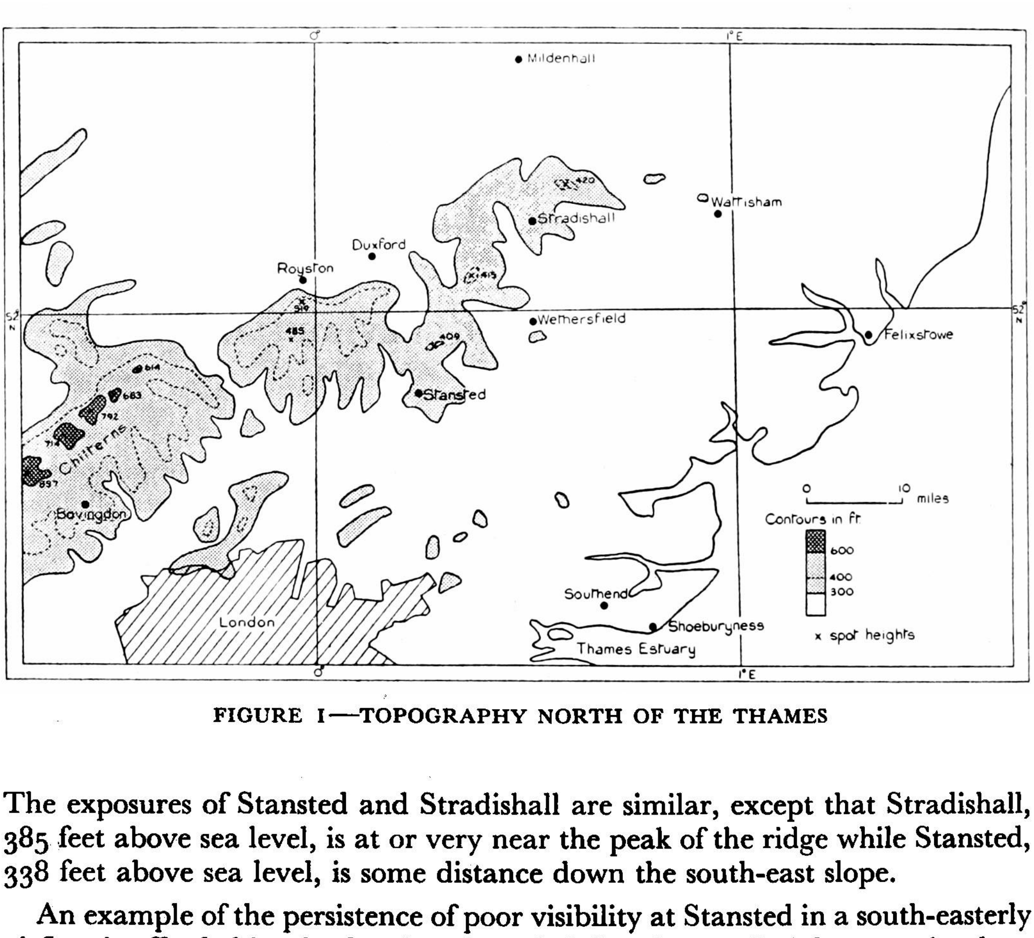


FIGURE 1—TOPOGRAPHY NORTH OF THE THAMES

The exposures of Stansted and Stradishall are similar, except that Stradishall, 385 feet above sea level, is at or very near the peak of the ridge while Stansted, 338 feet above sea level, is some distance down the south-east slope.

An example of the persistence of poor visibility at Stansted in a south-easterly airflow is afforded by the fog situation of 28 October 1958. A large anticyclone had passed slowly eastwards over southern England during the preceding few days and was centred over southern Germany on the morning of 28 October, and as a result a very slack south-south-easterly gradient existed over eastern and central England. An inversion of temperature of 20°F in the first 1,500 feet from the surface was shown by both Crawley and Hemsby ascents for midnight. Table I facing p. 334 shows the distribution of fog related to screen temperature and time in the area surrounding Stansted during that day. From this it will be seen that fog persisted throughout the day on the Essex coast at Shoeburyness while at Southend a similar persistence occurred except for one hour and a half in the early afternoon. The period of clearance became progressively longer as the distance of stations from the coastal area increased but, in spite of this, clearance at Stansted was no greater than at Southend and only varied in its timing. On the lee side of the East Anglian Ridge, however, at Duxford only 15 miles from Stansted, the period of clearance was in excess of seven hours. In view of the relatively short distance between the two stations on the same streamline, this difference can only be attributed to the effect of the intervening ridge. However, if this were so, a similar fog-free period might be expected at Stradishall as at Stansted, while on the occasion quoted, Stradishall remained clear of fog for five hours. These facts are not irreconcilable when the visibilities at the various stations during the fog-free period are compared. During this time, visibility at Stansted and Duxford remained in the range 1,500 yards to 2,200 yards and must therefore have been affected by much more smoke-polluted air than Stradishall, Wethersfield and Wattisham where visibilities were in the range 1½ to 2½ nautical miles, and since temperatures at both Stradishall and Duxford remained similar at that time, between 55°F and 57°F, a similar degree of turbulent and convective mixing of air should have existed at both stations.

The Table also shows an interesting similarity in conditions between Stansted and Bovingdon on this occasion in visibilities before and after clearance of fog, hour-by-hour temperatures and times of clearance and re-formation. Both are somewhat similarly placed on the ridge of high ground although this is a much more prominent feature in the Bovingdon area. The somewhat longer fog-free period at the latter station is probably due to a much longer land track of air, but the fact that both stations were affected by considerable smoke pollution does indicate the width of the London smoke source in a south-south-easterly airflow.

Although the example chosen was a typical fog situation, another type of synoptic distribution which has produced unexpected deteriorations to very poor conditions at Stansted is that in which a weak or stagnant front lies almost stationary or moves slowly across south-east England, usually with an orientation of the front from north-west to south-east. In such situations the pressure gradient to the north-east of the front is often relatively light and from the south-east quadrant, although in one occurrence the gradient was 190 degrees. Such fronts frequently lose most of their characteristics in the middle and upper atmosphere but a slight surface discontinuity persists and the air near the surface is almost always of very high humidity. With the movement of such systems into the Stansted area, stratus base has fallen to the surface or patches of fog have developed on a number of occasions when a cloud base of 300 feet or higher above the airfield or visibility in the range 1,100 to 2,200 yards had been expected, while on one occasion, although stratus was expected to fall to the surface, it did so some two to three hours before a similar occurrence at surrounding stations. In this type of distribution it has been noted that Bovingdon and Stradishall have often been affected similarly to Stansted but Southend and stations north of the Ridge have not.

Conclusion.—In agreement with the conclusions drawn at Stradishall, the up-slope action of the East Anglian Ridge is considered a significant entity in fog and stratus forecasting at this station with surface wind flow between south and east-south-east. A further factor is the smoke source of the lower Thames basin somewhat to the east of the main body of the London built-up area which is somewhat more likely to affect this station than those to the north-east. Moist winds from this quadrant thus call for an extra degree of caution in local forecasting.

REFERENCE

1. ATKINS, J. E.; Fitness figures as an aid in local forecasting. *Met. Mag., London*, **87**, 1958 p. 268.

THAW FOG

During the war there was a discussion on the incidence of thaw fog to which the following notes were some contributions. The discussion arose out of the publication of a paper by Petterssen[1], the argument of which was afterwards reproduced in his *Introduction to Meteorology*.[2] In his more recent *Weather Analysis and Forecasting*[3] he has made some further provisos regarding cases where temperatures are but little above freezing, but the frequency with which thaw fog occurs over the British Isles and western Europe justifies the reproduction of the wartime notes which are printed without alteration from their original form.

Fog over melting snow—the role of radiation

By C. S. DURST, B.A.

In a recent paper[1] Petterssen has asserted that (*a*) fog will not form over a surface covered with melting snow and (*b*) that if fog is carried over such a surface by advection it will tend to dissipate.

The basis of this assertion is that the air in contact with the snow will be saturated at 32°F. but temperature in the air above the surface will be greater than 32°F. Temperatures and absolute humidities will tend to increase from the ground upwards and there will, in consequence, be an eddy flux of moisture downwards. In consequence, it is argued, there is a deposition of water on the melting snow whenever the humidity exceeds certain limiting values dependent on the air temperature above the snow. The values, quoted from Petterssen's *Weather Analysis and Forecasting*[4] are given in Table I.

TABLE I

Air temperature (°C.)	Vapour pressure (mb.)	Relative humidity (per cent)
0	6·11	100
2	7·05	87
4	8·13	77
6	9·35	67
8	10·73	58
10	12·28	51

The inference is drawn from these figures that the higher the temperature of the air over the snow the less possibility there is of fog, and for fog to be carried by advection over a snow surface it would necessitate a very rapid supply of foggy air.

To make it quite clear what the problem is let us suppose that air at a temperature of, say, 40°F. and a relative humidity of 90 per cent (vapour pressure of 7·6 millibars) is over a snow surface. The temperature of the snow surface will rapidly rise to 32°F. and melting will occur, while the temperature of the air in contact with the snow will fall to 37°F. at which temperature it will be saturated. (The air at, say, five or ten feet will not fall to anything like the same extent.) Further cooling will cause deposition of moisture on the snow

TABLE I—VALUES OF VISIBILITY AND TEMPERATURE AT SELECTED STATIONS, 0600 TO 1700 G.M.T., 28 OCTOBER 1958

Time G.M.T.	Mildenhall	Duxford	Stradishall	Wattisham	Bovingdon	Stansted	Wethersfield	Southend	Shoeburyness	Felixstowe
0600	220yd 39°F	220yd 38°F	220yd 39°F		220yd 40°F	70yd 38°F		330yd	Under 110yd 45°F	770yd 49°F
0700	440yd 38°F	110yd 38°F	110yd 37°F	110yd 43°F	110yd 40°F	70yd 36°F		220yd	220yd 45°F	550yd 49°F
0800	2,000yd 39°F	880yd 38°F	330yd 37°F	220yd 43°F	110yd 41°F	100yd 36°F	1,100yd 37°F	220yd	110yd 45°F	220yd 49°F
0900	2NM 43°F	990yd 42°F	220yd 41°F	220yd 44°F	110yd 42°F	220yd 38°F	2,000yd 42°F	220yd	220yd 45°F	550yd 49°F
1000	2NM 49°F	1,300yd 46°F	220yd 43°F	220yd 46°F	110yd 43°F	110yd 41°F	660yd 43°F	220yd	330yd 46°F	2,600yd 49°F St 600ft
1100	2·4NM 57°F		1,400yd 47°F St 100ft	880yd 47°F	110yd 44°F	330yd 43°F	880yd 45°F	770yd	2,000yd 48°F	3,500yd 51°F St 300 ft
1200	5NM 61°F	1,800yd 56°F	2NM 51°F	880yd 49°F	330yd 45°F	110yd 45°F	2,600yd 50°F	990yd	550yd 48°F	2,000yd 50°F St 300ft
1230						110yd		(1220) 1,800yd St 300ft		
1300	5NM 61°F	1,600yd 56°F	2·5NM 56°F	2,800yd 51°F St 300ft	440yd 46°F	110yd 46°F	2,600yd 53°F	1,900yd	330yd 47°F	2·5NM 51°F St 400ft
1330						220yd (1335) 550yd				
1400	5NM 62°F	1,800yd 57°F	2·4NM 54°F	2,800yd 53°F	2,200yd 48°F	1,200yd 47°F	3NM	1,500yd St 500ft	330yd 47°F	2·4NM 52°F St 700ft
1430						1,500yd		660yd 48°F		
1500	5NM 61°F	1,800yd 55°F	2NM 55°F	3,500yd 52°F	2,200yd 50°F	2,200yd 51°F		550yd	110yd 47°F	2,000yd 51°F St 400ft
1530						2,200yd		220yd 48°F		
1600	4NM 59°F	1,500yd 52°F	3,500yd 53°F	220yd	1,600yd 50°F	(1545) 990yd 440yd 48°F		110yd	110yd 50°F	1,800yd 50°F St 100ft
1630					(1625) 770yd	80yd		110yd 52°F		
1700	2,500yd 53°F	1,400yd 49°F	30yd 48°F	110yd 49°F	550yd 47°F	90yd 47°F		110yd	110yd 51°F	1,500yd 51°F St 200ft

Note: In the above table, when fog was not reported, but a full or near full cover of stratus existed, a note is entered below the details of visibility and temperature; otherwise the sky was clear of low cloud. The horizontal lines divide visibilities above and below 1,100 yd.

(see p. 332)

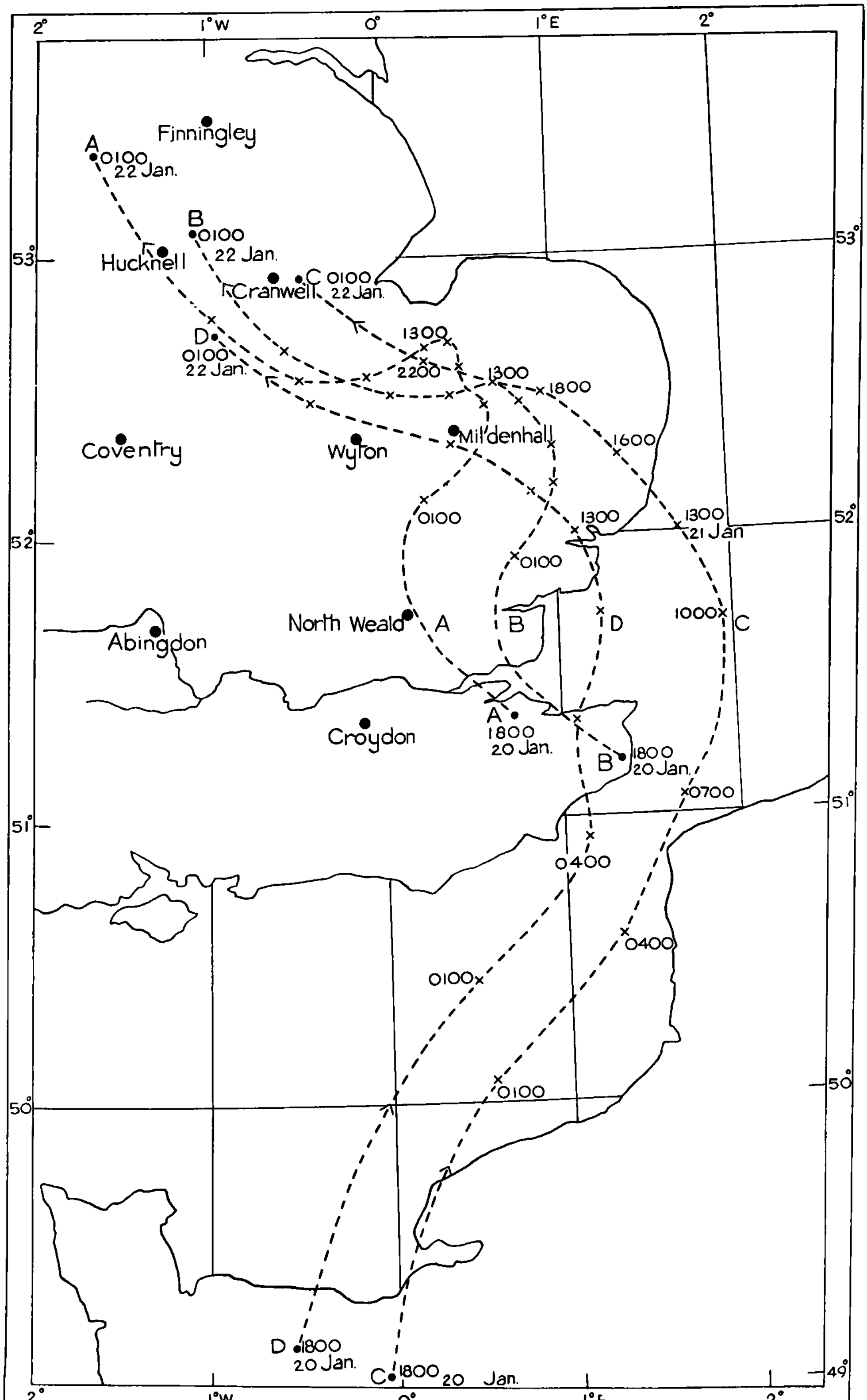


FIGURE 1—SURFACE AIR TRAJECTORIES FOR 21 JANUARY 1941

surface until the air in contact with the snow will have a temperature of 32°F. and a vapour pressure of six millibars. There will then be an increase of vapour pressure upwards. If the transfer of cooling upwards and the transfer of water vapour downwards is due to the same type of mechanism it might be expected that the drying process would be sufficient to counterbalance the condensation process due to the upward diffusion of cooling. But the air at, say, five or ten feet is not only cooled by mechanical diffusion upwards. Brunt[5] has shown that at any rate when there are surface inversions radiation is at least as important as mechanical diffusion and in a more recent publication[6] he gives reasons for believing that its importance is even greater than was originally expected. If this is so, Petterssen's argument will not necessarily hold for the rate of cooling at, say, ten feet by turbulence, and radiation may be substantially greater than the rate of drying of the air by downward transfer of water vapour. Quite likely very near the snow the fog might be cleared but not at heights which are of practical value.

If the surface is not frozen snow, and if warmer and moist air passes over it, the temperature of air in contact with the ground will be reduced and if it is reduced low enough, moisture will be deposited on the surface. At the same time there will be a definite tendency for the temperature of the surface to be raised to meet that of the air. Still the fact of deposition of moisture will even in this case tend to the formation of a gradient of water vapour increasing upwards, but the tendency for the earth's surface temperature to rise differentiates this case from that of the snow-covered surface. If the surface is water there will likewise be a deposition of moisture (which will mingle with the surface water); but since the conductivity of water is greater than that of earth and also because there will be eddy conductivity operating, the temperature of the water surface will not change appreciably and there will be created a definite gradient of water vapour increasing with height. The case then of the sea surface is very similar to that of the snow surface. Yet we know sea fogs over the Newfoundland Banks are very common. In this case also the effects of radiation may be of primary importance in outbalancing the physical process set out by Petterssen.

The blunt statement that fog tends to dissipate over a snow surface is contrary to the general experience of forecasters in this country, since thaw fog is known to occur frequently over snow cover and to persist. However, in order that specific instances may be examined some maps have been drawn of the occurrence of fog during the thaw of 21–23 January 1941.

For the case of fog over East Anglia on 21 January, when fog definitely occurred over a snow surface, trajectories have been drawn of the surface air flow for a period of about 30 hours. On this occasion an occlusion moved northwards over East Anglia and on the occlusion a depression developed. The ground was snow covered over East Anglia but over the southern part of the country snow was not lying.

Fog with visibilities of less than 200 yards occurred at many places in the rear of the occlusion which is the region to which the trajectories refer. The visibilities and dew-points along the four trajectories are given below (Table II). They can only be rough estimates interpolated from the stations on the three-hourly charts but they do appear to bring out some interesting features.

The trajectories may be divided into two pairs: A and B were over land all the time; C and D were mainly over the sea up to midday, then they turned inland and travelled for the next 12 hours over the snow. The visibilities and dew-points of the air over the sea are conjectural to some extent but the visibilities at coastal stations with onshore winds were in the range $1\frac{1}{4}$ to $6\frac{1}{4}$ miles and the normal sea temperature at that time of year is 42°F. It is, therefore, considered reasonable to give the visibility over the sea as between $1\frac{1}{4}$ and $6\frac{1}{4}$ miles and the dew-point as about 40°F. The air of the four trajectories was in the main one homogeneous mass, unlike the air just to the west of trajectory A which in the early stages at any rate was some 5°F. lower in temperature.

TABLE II—VISIBILITIES AND DEW-POINTS ALONG TRAJECTORIES OF THE AIR ON 20–21 JANUARY 1941

		A		B		C		D	
Date Jan.	Time G.M.T.	Visibility	Dew-point °F.	Visibility	Dew-point °F.	Visibility	Dew-point °F.	Visibility	Dew-point °F.
20	1800	1,100 yd.–$1\frac{1}{4}$ mi.	36	1,100 yd.–$1\frac{1}{4}$ mi.	38	—	—	—	—
21	0100	$1\frac{1}{4}$–$2\frac{1}{2}$ mi.*	37	$1\frac{1}{4}$–$2\frac{1}{2}$ mi.*	38	—	—	—	—
	0400	220–550 yd.*	37	220–550 yd.*	37	$2\frac{1}{2}$–$6\frac{1}{4}$ mi.	40	$2\frac{1}{2}$–$6\frac{1}{4}$ mi.	40
	0700	220–550 yd.*	34	550–1,100 yd.*	36	$2\frac{1}{2}$–$6\frac{1}{4}$ mi.	40	$2\frac{1}{2}$–$6\frac{1}{4}$ mi.	40
	1000	55–220 yd.*	35	220–550 yd.*	37	$2\frac{1}{2}$–$6\frac{1}{4}$ mi.	40	$1\frac{1}{4}$–$2\frac{1}{2}$ mi.	37
	1300	550–1,100 yd.*	37	550–1,100 yd.*	38	$1\frac{1}{4}$–$2\frac{1}{2}$ mi.	39	$1\frac{1}{4}$–$2\frac{1}{2}$ mi.*	38
	1600	550–1,100 yd.*	37	1,100 yd.–$1\frac{1}{4}$ mi.*	38	$1\frac{1}{4}$–$2\frac{1}{2}$ mi.*	38	550–1,100 yd.*	39
	1800	<55 yd.*	35	550–1,100 yd.*	39	1,100–2,200 yd.*	39	1,100 yd.–$1\frac{1}{4}$ mi.*	39
	2200	—	—	<55 yd.*	35	$2\frac{1}{2}$–$6\frac{1}{4}$ mi.*	40	220–550 yd.*	38

* Visibilities over snow surfaces.
The trajectories are reproduced in Figure 1.

In each case the dew-points remain reasonably constant but the visibility in every case decreases when the air gets over the snow, except perhaps in the case of trajectory C. Indeed, it is rather remarkable how the visibility remains in the range $1\frac{1}{4}$ to $2\frac{1}{2}$ miles in each case, when the air first comes over the snow, and then falls off. It may be noted that the temperature of the air is slightly above the dew-point before the fog forms, but as soon as the visibility sinks the air is reported to be saturated. Taking the mean temperatures of each trajectory in two parts, (*a*) before the visibility deteriorated and (*b*) after it deteriorated, the figures work out roughly as in Table III.

TABLE III—MEAN AIR TEMPERATURE IN CLEAR AND FOGGY AIR

Trajectory	Clear air	Foggy air	Difference
		degrees Fahrenheit	
A	37	$34\frac{1}{2}$	$2\frac{1}{2}$
B	39	37	2
C	40 (?)	$39\frac{1}{2}$	$\frac{1}{2}$(?)
D	$39\frac{1}{2}$(?)	$38\frac{1}{2}$	1(?)

Thus there appears to be a fall of about 2°F. in, say, 12 hours in the case of A and B, but rather less fall in the case of C and D. It is also interesting to note that the advection of the milder air will cause an inversion to occur while the process of melting the snow is going on. Indeed, that this inversion should be present, and its consequential diminution of turbulence, is essential to the mechanism which is being put forward in this paper to account for the presence of the fog.

That this inversion formed during the thaw in this particular case and that there was a diminution of turbulence in consequence can be seen from the anemogram from Cardington, reproduced in Figure 2. The character of the trace should be compared with Figures 30 and 55 of *Geophysical Memoirs*, No. 54.[7]

During the period from 0900 to 1800 G.M.T. on 21 January, the ground was covered with thawing snow at Cardington (since the general clearance for the district occurred during the night of 21–22 January). The trace from the anemometer is one showing little tubulence up to 1800 G.M.T., then the wind veered to south-east and the trace was affected by the eddies due to the airship sheds, as is discussed on page 49 of *Geophysical Memoirs*, No. 54, but by 0700 G.M.T. the wind had veered further and was no longer affected by these local eddies and the character of the trace became more normally turbulent. The diminution of eddying between 0900 and 1800 G.M.T. was at a time of day when normally turbulence produces much greater fluctuations than that shown on the anemogram: indeed, the type of trace shown is usually associated with a night-time inversion.

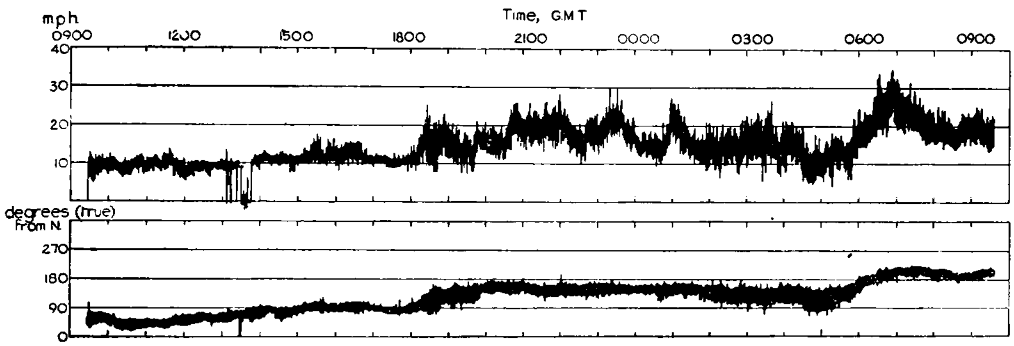


FIGURE 2—ANEMOGRAM FOR CARDINGTON, 21–22 JANUARY 1941

If the dew-point of the general stream is below 32°F. this stability will not necessarily be set up, but even when the air temperature falls to 32°F. fog drops will not form. Hence no fog can form over melting snow in that condition. If, however, fog formed over snow with a temperature *below* freezing then turbulence might give rise to a sufficient transfer of water vapour for the clearing of the fog to take place.

The conclusion is that if the dew-point of the air is above freezing point, fog will not be dissipated over a snow surface but is indeed likely to form. If the dew-point of the air is below freezing, fog is only likely to form if the snow is below freezing and only then will the fog dissipate as Petterssen describes.

Comments by S. F. Witcombe

The real point at issue is the layer in which this process is sufficiently effective. The steepest rise in temperature and in humidity is in the lowest one to three feet above the ground and the increase falls off rapidly above; in fact, most readings in a fog up to 500 feet are practically isothermal once the surface layers are left. Above the immediate ground levels the clearing tendency is, therefore, ineffective because of the small gradients and, during continued cooling, may easily be outweighed. This, I think, is the real reason why fogs close to the ground are less dense than at higher levels.

The small increase in the gradient of humidity downwards when the ground is snow covered does not affect the process except to hasten it slightly and then only in the bottom centimetre or so because the gradient above that level is then between waterdrop and waterdrop at increasing temperatures as the height increases.

The whole point seems to me to boil down to this. The formation of fog is a bulk process and what happens in the lowest feet does not affect the problem. Reduce your air mass in the free air below its dew-point and fog must and does form. How high the cooling must be carried for fog to be produced at any station depends on the local surroundings. In level country it is approximately 10 to 15 metres. In a valley it is the height of the station above the bottom of the valley plus 10 to 15 metres.

Comments by C. K. M. Douglas

It should be made clear that the note has a bearing on all fog caused by cooling at the surface, including radiation fogs in their early stages, and the majority of sea fogs. There seems little doubt that radiative diffusivity is important, and the recognition of this is an advance in our understanding of fog.

Even if diffusion takes place by turbulence alone, and K is the same for water vapour and potential temperature, there may be some condensation, since the Bezold mixing effect is not negligible. This effect can be expressed in a form more appropriate to a process of continuous slow mixing (including cases determined by cooling or warming at the surface), provided that the air is initially saturated. If the air is unsaturated, one would obviously have to introduce assumptions as to the relation between water-vapour content and temperature in order to treat the subject mathematically.

If the air is saturated, and w is water content per unit mass and T its potential temperature, then $\partial w/\partial t$ has a meaning derived from the ordinary curve of water-vapour content against temperature and if the air is just kept saturated without condensation,

$$\text{then} \quad \frac{\partial w}{\partial t} = \frac{\partial w}{\partial T}\,\frac{\partial T}{\partial t}.$$

Suppose w and T are changing owing to eddy diffusion,

$$\text{and let} \quad \frac{\partial w}{\partial t} = K\frac{\partial^2 w}{\partial z^2},\quad \frac{\partial T}{\partial t} = K\frac{\partial^2 T}{\partial z^2}.$$

$$\text{Then} \quad \frac{\partial w}{\partial t} = K\left[\left(\frac{\partial T}{\partial z}\right)^2 \frac{\partial^2 w}{\partial T^2} + \frac{\partial w}{\partial T}\,\frac{\partial^2 T}{\partial z^2}\right]$$

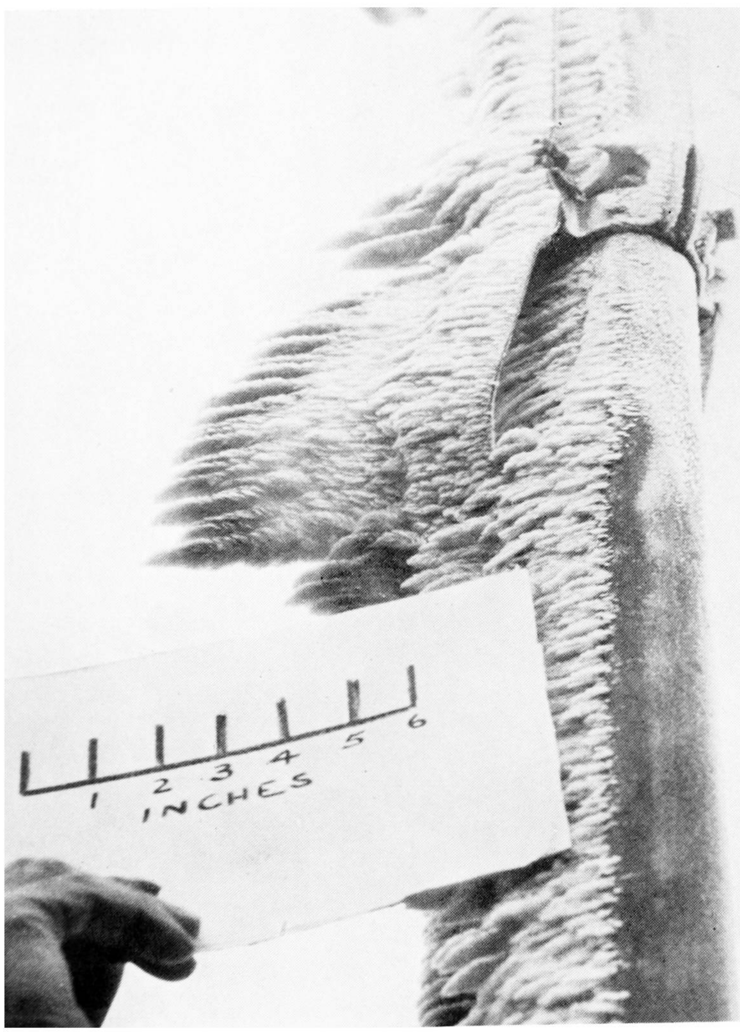
$$= K\left(\frac{\partial T}{\partial z}\right)^2 \frac{\partial^2 w}{\partial T^2} + \frac{\partial w}{\partial T}\,\frac{\partial T}{\partial t}.$$

The first term on the right is always positive and indicates that when there is eddy diffusion in saturated air and the lapse rate differs from the adiabatic there is always condensation, whether the net change of moisture content is positive, zero or negative. This obviously must be so from the well known Bezold relation. The amount of condensation is small but not negligible.

If we take $K = 10^4$ cm.^{2} sec.$^{-1}$

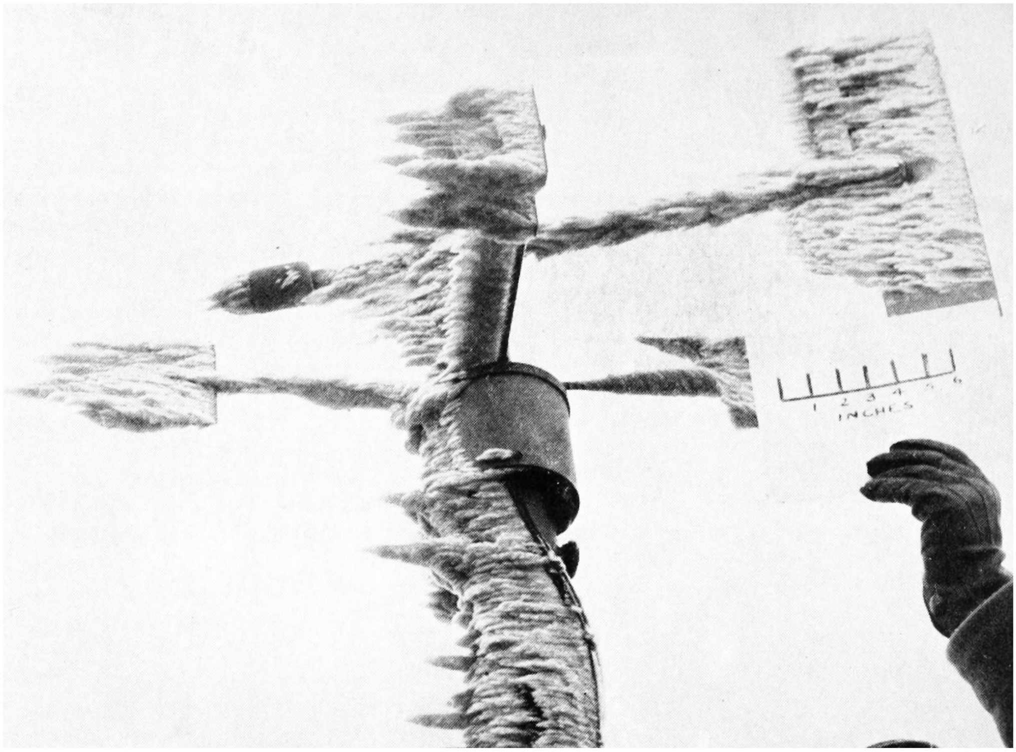
$$\frac{\partial T}{\partial z} = 20^\circ\text{C. km.}^{-1} \text{ (inversion)}$$

$$\frac{\partial^2 w}{\partial T^2} = 0{\cdot}3 \text{ gm. kg.}^{-1}\,(^\circ\text{C.})^{-1}\,(^\circ\text{C.})^{-1}.$$



RIME ICE IN THE COTSWOLDS, FEBRUARY 1959

To face p. 339]



RIME ICE IN THE COTSWOLDS, FEBRUARY 1959

Then the condensation per second is $10^4 \times (2 \times 10^{-4})^2 \times 0{\cdot}03 = 12 \times 10^{-5}$ gm. kg. $^{-1}$ of dry air. The amount per hour is 0·043 gm. m. $^{-3}$, about 0·04 gm. m. $^{-3}$. This would be appreciable after some hours. Köhler[8] found a water content in fog generally below 1 gm. m. $^{-3}$, sometimes as low as 0·25 gm. m. $^{-3}$. The much higher water content found long ago by Conrad and Wagner in many of their cases must either have been erroneous or abnormal.

Considering that the air does not start saturated it is clear that mixing cannot be the main factor in fog formation and that radiative diffusivity must come in. Once a fog has formed the radiation from the fog itself is important and when the fog extends above 500 feet a lapse within the fog may replace the inversion, and the fog may eventually lift slightly off low ground even at night with very little wind (for example, 23–24 November 1936). This is less likely in the case of a thaw fog than in the case of radiation fog, as there is often cloud above, and surface cooling on the ground may be more effective than when there is a thick fog and no snow cover.

Comments by F. H. Dight

Mr. Dight pointed out that owing to the föhn effect at Oslo the air over the snow there might be considerably drier than we were accustomed to in the British Isles, and that this might account for the different behaviour in the two places, and referred to an effect he had noticed at Farnborough and Croydon, where he had seen mist on frosty mornings persisting, however bright the sunshine, until all the hoar frost had cleared from the ground when visibility immediately improved rapidly.

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NOTES AND NEWS

Rime ice on the Cotswolds—February 1959

During the period 6–9 February 1959 thick fog covered the higher ground of the Cotswolds, persisting throughout the period with temperatures slightly below freezing. The temperature was between 28–32°F, and the wind east to south-easterly light or fresh.

This resulted in a freezing out of water droplets and a thick coating of rime ice gradually accumulated over all exposed objects, thickening and growing to such an extent that telephone wires and telephone poles were brought down and some trees snapped under its weight.

The ice became crystalline and its structure layered like a feather, as can be seen from the photographs between pp. 338–339. The ice was not brittle but was fairly dry. It did not thaw out quickly in the hand. The colour was rather on the dark grey side—probably due to smoke.

The average spread of the rime ice was between 3–4 inches but 5–6 inches was not uncommon, as can be seen from the inch scale or from the penny coin on the tree branches, as shown on the photographs, which were taken on the morning of the 9th. The ice melted rapidly during the thaw which began in the late afternoon of the 9th.

J. KONIECZNY

The closing of Croydon Airport

Croydon Airport closed on 30 September 1959 after a varied career of some 44 years.

Croydon Aerodrome was opened in 1915 by the Royal Flying Corps. On 28 March 1920 it was taken over by Civil Air Transport when it became known as Croydon (Waddon) Aerodrome, the air terminus for London. The terminal buildings and offices were but a collection of ex-service huts situated alongside Plough Lane to the west of the aerodrome. One of these huts was allocated to the meteorological office and it is on record in a Stationery Office notebook that the first observation was made at 0700 G.M.T. on 8 March 1920. On 29 March 1920 observations were commenced throughout each 24 hours and they have continued without a break until now, except for a few days after 18 August 1940 when the terminal building was bombed and the instruments destroyed with the exception of the sunshine recorder which maintained its unbroken record to the end.

The development of transport aircraft soon outstripped the capabilities of the wartime accommodation and on 2 May 1928 an imposing structure was opened alongside the Croydon by-pass on the London–Brighton road to be the terminal building of the "Airport of London" which was then the most modern airport in the world. With the changeover to the new terminal building in 1928, the meteorological office was contained in a suite of rooms on the first floor beneath the control tower. Communication facilities with control were excellent and, in the early days at least, there was floor space in plenty for forecast benches.

Croydon must mean so much to so many of the Meteorological Office staff. Looking back through the records, many familiar names of all ranks occur—and some recur. The hall-mark of an Assistant could be that he was trained at Croydon and there was no better experience for a forecaster than to have had a session at the Croydon bench. Perhaps the greatest of Croydon's attributes has been the traditional understanding and friendliness of all aircraft operators with the meteorologists, for it is upon that that the best briefings are bred.

The register store at Croydon is a silent witness to progress. First, on 8 March 1920 the Stationery Office notebook mentioned above, then on 29 March 1920 a proper register (Form 3410, size seven inches by five inches). This was sufficient until 1 July 1921 when it was deemed necessary to expand to Form 2003 (size ten inches by six inches). This lasted quite a while until 21 December 1949 when Form 2050 came into use (size thirteen inches by eight inches) and finally on 1 January 1952 the present register (size eleven inches by eleven inches).

Among the officers in charge of the meteorological office were:— G. R. Hay, M.A., S. F. Witcombe, B.Sc., R. S. Read, I.S.O., M.A., B.Sc., A.R.C.S., F.Inst.P., W. L. Lineham, D. F. Bowering, M.B.E., and E. L. Clinch.

Director of the Canadian Meteorological Service

Dr. Andrew Thomson, O.B.E., F.R.S.C., retired on 25 September 1959 from the position of Director of the Canadian Meteorological Service. He has been succeeded by Mr. P. D. McTaggart Cowan.

Dr. Thomson's first post after graduating in physics from the University of Toronto was with the Department of Terrestrial Magnetism of the Carnegie Institute of Washington. He was in charge of investigations into atmospheric electricity during a 26-month cruise round the world made by the Institution's research ship *Carnegie* in 1920–21. In 1923 he became Director of the Apia Observatory, Samoa, and in 1929 Aerologist of the Dominion of New Zealand. He returned to Canada in 1931 to become Chief of the Research Division of the Meteorological Service. He was promoted to Assistant Controller in 1939 and assumed charge of the whole Service in 1946.

In the international meteorological field Dr. Thomson was for many years a member of the Executive Committee of the World Meteorological Organization and President of the Regional Association of the World Meteorological Organization for North and Central America. He was awarded the O.B.E. in 1948, the degree of Doctor of Science *honoris causa* by McGill University in 1958 and the Gold Medal of the Professional Institute of the Public Service of Canada in 1952.

His many friends among British meteorologists will extend to Dr. Thomson their best wishes for a long and active retirement.

Account of weather and table of rainfall

In order to provide more space in the *Meteorological Magazine* for scientific articles and so reduce the time interval between acceptance and publication of them, it has been decided to cease publication in the Magazine of the account of the weather and table of rainfall with effect from those for December 1959.

Transliteration of Cyrillic alphabets

The Meteorological Office has adopted for editorial and library purposes with effect from 1 October 1959 the international system of transliterating the Cyrillic alphabets used by most Slavonic languages. The most important of these alphabets is Russian Cyrillic.

The international system was devised by the International Organization for Standardization and is recommended and used by the World Meteorological Organization. The international system is published in British Standard 2979:1958, *Transliteration of Cyrillic and Greek characters*, and in the World Meteorological Organization publication *Guide to meteorological library practice*.

OBITUARIES

Charles Samuel Herbert.—It is with great regret that we record the death on 4 October 1959, at the age of 61, of C. S. Herbert. It was on 1 January 1912, just before his 14th birthday, that Herbert joined the Meteorological Office as an office boy in the General Services Division. He remained there until 1924 when he was transferred to the Forecast Division. From 1930 to 1943 he served successively at the aviation stations at Croydon, Mount Batten, Ismailia and at several other places in the Middle East. In 1943 Herbert returned to the United Kingdom to join the Instruments Branch, then located at Stonehouse, Gloucestershire. He remained in the Branch until his retirement in April 1957, having been the Senior Experimental Officer responsible for the provision of instruments for his last 10 years at Harrow.

Herbert was on active service in the Forces in both World Wars—in the First World War in the Royal Engineers (Signals) and in the Second as a Flight Lieutenant in the Royal Air Force Volunteer Reserve. He was "Mentioned in Despatches" in June 1943.

For some years before his death Herbert suffered serious ill-health, involving the removal of a lung and the loss of his voice, but he bore these troubles remarkably cheerfully. He had a quiet, kindly disposition and a charm of manner which made him a good colleague. His many friends in the Meteorological Office will feel sad that his well earned retirement after 45 years' service should have been so brief and they offer their deepest sympathy to his wife and daughter.

Mr. Thomas Holland Parry.—It is with deep regret that we learn of the death on 8 October of Mr. T. H. Parry, Senior Experimental Officer, at the age of thirty-eight. He joined the Office in October 1939 as a Technical Assistant III and all his service was spent at aviation outstations including a tour of duty in Aden. At the time of his death he was serving at London Airport. He is survived by a widow, two sons and one daughter to whom the sympathy of all who knew him is extended.

Mr. John Howard Winstone.—It is with deep regret that we learn of the death on 16 October of Mr. J. H. Winstone, Assistant (Scientific), at the age of twenty-nine. He joined the Office as a Meteorological Assistant in March 1947. His first three years' service was spent at aviation outstations. Since 1950, apart from a period from 1954 to 1956 which he spent with the Falkland Islands Dependencies Survey, he served at radio-sonde units including two tours of duty overseas and one voyage in an ocean weather ship. At the time of his death he was serving at Bahrain. He is survived by a widow and a baby daughter to whom the sympathy of all who knew him is extended.

METEOROLOGICAL OFFICE NEWS

Retirements.—The Director-General records his appreciation of the services of:—

Mr. R. G. Veryard, Deputy Chief Scientific Officer, who retired on 24 October 1959. He joined the Office as a Technical Assistant in May 1919 after service in the Royal Flying Corps and the Royal Air Force in the First World War. His first few months were spent at Kew Observatory and later that year he was transferred to Shoeburyness where he remained until 1923 when he was transferred to the Instruments Division. In 1925 he was posted to the General Climatology Division, and later in that year he was seconded for duty with the Royal Air Force in India. He returned to the Office in 1936 and was posted to the Forecast and Aviation Services Division. In 1938 he was transferred to be Senior Meteorological Officer, Headquarters No. 4 Group, Royal Air Force, where he remained until 1941 when he returned to Headquarters to be Head of the Royal Air Force (Home Commands) Division. In 1946 he was transferred to the Middle East to be Chief Meteorological Officer and he remained there until 1949. On his return he was attached to the Director's office for special duties, mostly of an international character. Early in 1953 he became Assistant Director (Climatological Services) at Harrow, and in 1958 he was promoted to Deputy Director (Central Services). In January 1957 he was elected President of the Commission for Climatology of the World Meteorological Organization. Mr. Veryard has accepted a temporary appointment in the Meteorological Office.

Mr. A. A. V. Buchanan, Senior Experimental Officer, who retired on 19 October 1959. He joined the Office in November 1926 after service during the First World War in Palestine and France and later in the Royal Air Force. From 1922 to 1924 he served as a Royal Air Force meteorologist in Iraq. His first nine years in the Office were spent at aviation outstations. In 1935 he was transferred to Headquarters where, apart from a period from 1939 to 1940 when he again served at aviation outstations, he served continuously until his retirement in the section concerned with the collection and distribution of synoptic information. Mr. Buchanan has accepted a temporary appointment in the Meteorological Office.

Mr. A. E. Mayers, Senior Experimental Officer, who retired on 31 October 1959. He joined the Office in March 1921 as a Technical Assistant and was posted to Shoeburyness where he remained for nine years. In 1930 he was transferred to Cardington and after briefs spells at Headquarters in the Forecasting and Instruments Divisions between 1932 and 1934, he was posted to Porton. Since 1936 he has served successively at a number of aviation outstations. From 1954 until his retirement he served at Watnall.

REVIEWS

Everyday meteorology. By A. Austin Miller and M. Parry. 9 in. × 6 in., pp. 270, *illus.*, Hutchinson & Co. Ltd., 178–202 Gt. Portland Street, London, W.1, 1958. Price: 30*s*.

The reviewer needs to reveal at once that, having had some forecasting experience, he now finds himself in what the authors call "a quieter backwater of our meteorological organization". Perhaps the explanation of his problem lies in advancing years, but, in any event, he has attempted not to be conditioned by this remark.

The authors, well known geographers of the University of Reading, have written this popular (not one overt equation) book to give the layman some insight into the science of the weather and to broaden his perception of its importance to the community. They have done a very good and very readable job and have packed a great deal of information into its pages. The usual familiar (to the professional) ground is faithfully covered—gathering and assembling of information, causes of weather, air masses, fronts and so on—but there is little, understandably enough, on upper air analysis beyond the usual aerological diagram material. Inevitably there are minor inaccuracies but one has to bear in mind the type of reader for whom the book was written.

There are chapters on local weather and the problems of forecasting. The first of these could have been expanded, for example, there is no mention of the absence or infrequency of showers by day in the summer half-year in some coastal areas with onshore winds, when these may be quite frequent inland. Many a holidaymaker at Blackpool has, quite unconsciously, been happier on this account. This chapter, whilst it covers the stock ground does not meet one of the stated aims to enable the reader to "judge for himself from an understanding of the effect of local weather-generating factors". But this is a difficult aim and the authors made it clear that to those to whom weather is money there is no real substitute for consulting a professional.

I felt that one of the authors thoroughly enjoyed writing the chapter on "Living with the weather" and "Weather in harness". There is much material put very succinctly here, which even some professionals might find rewarding reading. Indeed, possibly because of present interests, I was sorry that there was not more of this even at the expense of some of the earlier synoptic-type material.

R. H. CLEMENTS

Introduction to meteorology. By Sverre Petterssen. 9 in. × 6 in., pp. x + 327, *illus.*, McGraw-Hill Publishing Company Ltd., 95 Farringdon Street, London, E.C.4, 1958. Price: 52*s*. 6*d*.

The appearance in 1956 of a revised edition of *Weather analysis and forecasting* by Dr. Petterssen was welcomed widely by synoptic meteorologists. No less welcome should be the completely revised second edition of his *Introduction to meteorology*. It is seventeen years since the book was first published and after that lapse of time even an elementary text can become very dated. This new edition with its handsome binding, illustrations and wealth of clear diagrams is likely to make a ready appeal to the reader with some scientific training but little or no knowledge of meteorology. In selecting his material, Dr. Petterssen has ranged over a very wide field and drawn on sources as varied in time as the *Old Testament* and the results gained from instruments carried by rockets.

It has been the author's deliberate aim to reduce the number of numerical relationships and symbols to a minimum and stress is placed on the significance of interaction between the surface of the earth and the atmosphere in determining weather and climate. Considerable attention is rightly given to the economic importance of weather and climate, particularly in relation to agriculture. The space devoted to forecasting techniques, however, is negligible, an omission justified by the author on the grounds that the subject is too technical for adequate treatment in an elementary general book.

The book opens with a review of the structure and constituents of the atmosphere from the surface to the ionosphere, but while there is much here to excite interest in the upper air, it is a pity that the distinction between the weight of an air column and pressure is not always made clear. Descriptions of the commoner meteorological instruments used for surface observations follow.

Further chapters deal with clouds, condensation and precipitation. Here cloud physics is introduced with descriptions of the ice-crystal and capture processes involved in the release of precipitation from clouds. It is disappointing, however, to find that the illustrations of cloud types are still those used in the first edition; by modern standards these reproductions leave much to be desired. Moreover, a number of descriptive terms employed—densus, castellatus, fractonimbus—are not used in the new World Meteorological Organization *International cloud atlas*.

Heat and temperature changes are next described, followed by a clear account of convective activity in the atmosphere; in dealing with thunderstorms an example is given of analysis on the "meso" scale. After a brief chapter on visibility the laws of motion are discussed; the mathematical treatment is elementary. This leads naturally to local winds and winds at all levels over the earth. There is little new in the sections of the book dealing with air masses, fronts, depressions and anticyclones. It is notable, however, that long waves receive a mention and the Rossby formula for calculating their speed is given. An interesting chapter devoted to tropical storms contains good diagrams and a striking radar photograph. Three chapters are spent on a description of the temperature and precipitation regions over the world and the division of the earth into climatic regions after Köppen. The book ends with some brief comments on weather lore and weather forecasting.

There are no references to technical literature. On the other hand, there is a useful glossary of technical terms and their derivations, a list of books recommended for further study, some tables and an adequate index. There are a number of misprints, but in few instances should they lead to confusion. However, on page 84 it is stated that "Normally the mixing ratio will increase from the ground upwards." Surely "decrease" was intended?

H. B. ROWLES

Natural aerodynamics. By R. S. Scorer. 8½ in. × 5½ in., pp. xii + 312, *illus.*, Pergamon Press Ltd., London, 1958. Price: 60*s*.

This book is a refreshing change from the more formal type of textbook usually associated with branches of dynamics. Imaginative argument is used, not so much to solve problems or prove theorems, as to form a philosophical approach to the study of real fluid motion with particular reference to the air around us.

The first four chapters of the book describe the roles played by inertia, geostrophic forces, vorticity and viscosity in fluid motion. Natural examples range from the behaviour of large bubbles in water to the atmospheric implications of Sutcliffe's development equation. Fronts are introduced as part of the paradox whereby nature accentuates density gradients in the very process of smoothing them out. Two chapters on boundary layers, wakes and turbulence touch on such topics as the dendritic forms of snowflakes, jet flaps and vortex generators on aerofoils, dynamic soaring by albatrosses and the capture of cloud droplets by raindrops.

The descriptive style used by Dr. Scorer should be familiar to readers of *Weather*. Argumentative paragraphs interspersed with sketchy, but adequate, formulae are used to probe the processes being described, and this style is particularly well suited to a chapter on buoyant convection. After a brief discussion on slow convection in shallow layers, the exploitation of atmospheric convection currents by glider pilots, birds and insects is interpreted in the light of water tank experiments. These experiments focus attention on the observed behaviour of clouds of heavy fluid released in a tank of water, and plausible argument links the tank observations with some aspects of atmospheric convection.

Many of Dr. Scorer's arguments are founded on his own observations not only in the laboratory but in the town and country. Indeed he is an ardent smoke watcher, and while expressing horror at the obnoxious effluents polluting the skies of civilized lands, he is quick to discern in smoke plumes the "delightful mechanisms of dispersion employed by nature". In a chapter on plumes and jets the mathematics of these mechanisms are enlivened by shrewd analysis of the patterns of smoke plumes he has observed.

Leaving local for larger scale phenomena the next chapter includes a commentary on explosion waves and tidal waves. Since mountain waves and jet noise are also included in this chapter, none of these types of air waves is dealt with at length. Nevertheless their fundamental properties are adequately described. Rather more detailed treatment is given to clouds and fallout, the word "fallout" being substituted for "precipitation" in the meteorological sense. After describing the tephigram Dr. Scorer extends the earlier discussion of convection to shower development, thunderstorms and convection in a stable environment. The transformation of thin layer clouds by elevation, subsidence, glaciation and radiation is also allotted several pages in this chapter.

The final chapter comprises a philosophical commentary on the mathematical, physical and geographical approaches to problems on natural aerodynamics. Cautionary advice on the use of dimensional analysis, numerical coefficients, perturbation technique and extrapolation is given before the reader is finally invited to distinguish between the technological process of posing problems for solution and the purely scientific method in which a precise question is difficult to frame until its answer is known.

With a little over 300 pages in the book, it is too much to expect the author to do more than sketch the basic concepts associated with each of the various topics mentioned, but it is apparent that the book is not meant to be a comprehensive textbook on natural aerodynamics. The obvious, and achieved, aim is to help student meteorologists, mathematicians, aerodynamicists, geographers and kindred scientists to be logical, imaginative and observant in studying fluid motion. The student should find in the book many a starting point for further research, and for the professional meteorologist there are many intriguing snippets of information and argument not normally included in his formal training and experience.

C. E. WALLINGTON

Physikalisch-Statistische Regeln als Grundlagen für Wetter-und Witterungsvorhersagen. Band II. By F. Baur. $10\frac{3}{4}$ in. $\times 7\frac{3}{4}$ in., pp. iv+152, *illus.*, Akademische Verlagsgesellschaft M.B.H., Frankfurt am Main, 1958.

This handsomely produced book completes an important two-volume work in which Baur, the head of the former German long-range forecasting research institute established in 1929 at Frankfurt am Main by the Ministry of

Agriculture for Prussia, presents his main contributions to the science of weather forecasting.

The first volume, published in 1956 and reviewed in the *Meteorological Magazine*[1] in November 1958, was concerned with statistically established rules about the behaviour of the general atmospheric circulation as an aid to forecasting up to a few days ahead. Connexions investigated between the large-scale weather pattern and solar events (from the 11-year sunspot cycle to the short-lived individual outbursts) introduced the topic of longer term weather development. The new volume, specifically devoted to the problems of monthly and seasonal forecasting, is perhaps the more interesting of the two, dealing as it does with a branch of forecasting which, as far as Europe is concerned, Baur was the first to open up on a scientific basis. Although the whole work is much concerned with the scientific basis of the methods presented, this second volume is to some extent a practical handbook of long-range forecasting—so far as the reviewer is aware, the first in the world.

Baur's starting point was an at first intuitive dissent from a point of Schmauss's in an otherwise good course of lectures on meteorology at the University of Munich in 1919. Schmauss held that a meteorological fluke (the chance that determines rain or snow when very near the critical temperature) might make a big and lasting difference to the weather development in a given season, and that therefore it would never be possible to forecast more than about 36 hours ahead. Baur set to work to show that, by physical reasoning about the factors controlling the seasonal development of the circulation, it would be possible to find rules which, once the physical circumstances were adequately expressed, the circulation development always followed. These rules are to be conceived as special applications of the universal laws of physical science to the particular circumstances.

The philosophy of the method of attack has been that what experiment is to the general physicist statistics, with significance tests as its instruments, can be to the meteorologist. Since the meteorologist cannot control his experiments as the physicist does in his laboratory, arranging that all the variables except one are held constant, he must consider so great a number of cases that every possible variation occurs many times. The meteorologist can then select the cases which correspond to any prescribed set of circumstances: in this way he makes sure of "other things being equal" by his own choice. Baur has stressed again and again in his writings that statistical investigations in meteorology are only of value when they are guided by physical reasoning—that is, when the "experiments" are chosen to solve what are basically physical problems.

Baur does not claim that detailed physical understanding is yet possible either of the seasonal development of the atmospheric circulation or of solar influences upon it, though the broad outlines may be and there are interesting chapters on both. He points out that we shall not know the full extent of solar influence until we know the true "solar constant", that is, until we have seen the full spectrum (possibly to be revealed by sputnik observations) complete in the ultra violet, before the beam reaches the Earth's atmosphere and starts producing ozone. The reviewer noticed some apparent discrepancies between Baur's interpretation of the 11-year sunspot cycle and that of Scherhag[2], who points to sudden phase-shifts in the associations with atmospheric phenomena after every fourth sunspot cycle. Professor Allen's curves[3] suggest a possible double oscillation (of small amplitude) in the solar constant during two sunspot cycles in the 1920s and '30s, with maximum solar output between the sunspot extremes as required by Baur, but by the 1947 maximum both curves were apparently running parallel. Until the physical controls are understood fully and in detail, there is an obvious danger in proceeding with long-range forecasting that the statistical experience of the past may prove unhelpful in new circumstances in the future.

The book shows the normal seasonal development of the atmospheric circulation both by curves of five-day normal pressures for places all over Europe and by graphing the trend throughout the year of the correlation coefficient of 10-day mean pressure at Potsdam (1893–1936) with the mean pressure for the next 10 days. This correlation coefficient is positive (tendency for persistence) at most times and exceeds $+0\cdot4$ in peaks about New Year and about 15 July (St. Swithin's day); it falls to zero or small negative values at times in March, April and May with their characteristically changeable weather and has one longer period of negative values culminating with $-0\cdot22$ around 20 June corresponding to Europe's best-marked change of natural season, when the prevailing patterns of the atmospheric circulation undergo a decided change over much of the hemisphere. These data tie in well with the singularities and natural seasons to be observed also in British weather.[4]

How far Baur has managed to get towards his goal of establishing a scientific method of long-range weather forecasting may be judged after reading the book. He says himself that the manifold variety of the atmospheric circulation means that one needs to define a very large number of rules to cover all circumstances. In this book he gives 54 rules which have worked with over 90 per cent reliability in large numbers of cases, and of these 31 have so far never failed. It is taken as a fundamental principle that long-range forecasts should only be given, at least publicly, when statistical relationships beyond the limit of chance (based on a 3σ criterion) ensure a 90 per cent or greater chance of success of forecast; the probability and basis of reasoning are generally stated in the forecast. If the material in this book had been fully compiled in time to forecast the temperature characteristic of the winters 1945–58, rules applicable to 10 of the 13 winters would have been found and of the 14 forecasts which could have been made for the winters or parts thereof 13 (93 per cent) should have been successful. The one failure (the cold February of 1956) is attributed by Baur to solar events; whether this be disputed or not and whether we believe that any of the other physical interpretations in the book could be improved upon, Baur's success at formulating and tackling large-scale circulation and long-term weather problems commands the highest respect and attention.

Work on similar lines on empirical study of the general circulation is amongst the most promising developments in several countries today. This research has an acknowledged debt to the ideas of Bergeron[5] but may be spurred on almost equally by the methods and achievements of Baur in long-range forecasting.

H. H. LAMB

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Planetary and space science, Vol. 1, No. 1. Editor-in-Chief, M. Greenberg. 9¾ in. × 7½ in., pp. 84, *illus.*, Pergamon Press Ltd., 4 & 5 Fitzroy Square, London, W.1, January 1959. Price: £7 per volume.

We welcome this appearance of this international research journal which is designed as a new medium for publication of recently acquired information on the earth's atmosphere, inter-planetary space and related topics. The Editors and their Advisory Board comprise many of the leading workers and experts in the astronomical, ionospheric, upper atmospheric and meteorological fields from many countries, including Russia, and the aim is to publish only original papers on these subjects. It seems unlikely that there will be any lack of material for, as pointed out by Professor A. C. B. Lovell in a foreword to the first number, the increasing accumulation of new data now being obtained by improved astronomical techniques including radio methods, rockets and satellites is vast and needs new openings for publication on an international scale.

As would be expected, with its distinguished editorial board, the standard of papers (whose authors are all American or Russian) in the first number is very high. The subjects include amongst others spectroscopic studies of the night sky and aurora by rocket and surface observations, laboratory and theoretical investigations; micrometeorite measurements from satellites and a study of the mass and composition of the Grant meteorite; investigations relating to the spin and re-entry of satellites; the derivation of a standard atmosphere from rocket and satellite data; an attempt to account for the diurnal, seasonal and latitudinal variations of the upper atmosphere in terms of possible energy sources; finally, subjects of astronomical interest including the airglow of Venus and measurements with a travelling-wave tube radiometer of absorption, refraction and scintillation in the solar beam.

In addition to the publication of results of research there is an international announcement giving the Charter of COSPAR, the Committee on Space Research set up in 1958 by the International Council of Scientific Unions with the object of fostering fundamental space research through international co-operation. Finally, there is an interesting article by W. W. Kellogg reporting the Moscow meetings of August 1958 at which the preliminary results of the International Geophysical Year rocket and satellite programmes were presented. Clearly, if subsequent numbers are as informative as this first number, and there is every reason to expect that this will be so, a very important addition will have been made to the world's literature on these subjects.

R. J. MURGATROYD

WEATHER OF AUGUST 1959

Northern Hemisphere

Cyclonic activity over the Atlantic was weaker than usual and there were few depressions deeper than 990 millibars. Anticyclones were centred regularly near the Azores during the first half of the month but during the latter part centres were mainly close to or over the British Isles. On the mean pressure chart there was a strong north-eastward extension of the Azores high across central and northern Europe with anomalies of +6 millibars over the North

Sea and southern Scandinavia. The largest anomalies in the hemisphere were associated with the usually intense polar anticylone which had a central pressure of 1021 millibars compared with the average August value of 1013 millibars. Over Asia negative anomalies predominated, the monsoon low being 3 millibars deeper than usual, and over North America the largest anomalies were −4 millibars in Nebraska.

A large area of Europe experienced unusual warmth during the month and mean temperatures 3°C above average in parts of Britain, southern Sweden and northern Germany were a direct consequence of the prolonged anticyclonic conditions. Similar anomalies occurred in the northern coastal regions of Russia but further south there was an area with cooler conditions than usual near the Caspian Sea. Anomalies of −2°C and −3°C were also reported around the eastern Mediterranean and along the coasts of eastern Greenland and northern Iceland where they were presumably a result of the delayed break-up of ice and an excess of cold melt water. In North America temperatures were above average over most of the United States and eastern Canada, anomalies reaching +4°C around the Great Lakes, and below the average over central and western Canada, the largest anomalies being −4°C east of the northern Rockies.

It was exceptionally dry over a large area of Europe including the British Isles but there were some large excesses of rainfall over Iceland, Spitsbergen and northern Scandinavia. The pattern of precipitation was very irregular over central and southern Europe on account of thunderstorms and locally heavy rain in weakly cyclonic situations. In particular, violent storms over central Spain on the 7th caused much damage, and between the 11th and 13th heavy, continuous rain over Austria was followed by widespread flooding. Over North America the rainfall distribution was quite variable. Totals were variable too in the Indian monsoon area and south-east Asia. During the month eight typhoons (twice the average number) were reported between the South China Sea and Japan. Some of these were particularly violent and caused widespread damage as they crossed land areas. On the 9th, Formosa experienced the worst floods for 60 years and 260 lives were reported to have been lost. Later in the month the mainland opposite Formosa was affected by an equally severe typhoon, while the worst drought for many years was reported in northern and central provinces of China.

WEATHER OF SEPTEMBER 1959

Great Britain and Northern Ireland

The anticyclonic conditions which had dominated the weather during the previous four months continued throughout September apart from a short break about the 20th–21st. Most places in England and Wales were virtually without rain during the first three weeks of the month.

An anticyclone was centred over the North Sea during the first eleven days of the month. Afternoon temperatures, which were in the upper sixties at the beginning of the month, rose steadily and from the 6th to 12th exceeded 80°F somewhere in Britain every day; on the 11th Gatwick recorded 86°F. On the 12th the anticyclone became centred off north-west Scotland where it remained until the 17th. Weather became cooler although temperature exceeded 70°F locally, and it remained dry apart from a few slight showers in eastern districts.

Subsequently the anticyclone moved south-east but there was little change in the weather until the 20th when an active cold front with fairly substantial rain moved into Northern Ireland and north-west Scotland. Rain became widespread on the 21st and was heavy at times in the north and Midlands, but amounts were small in the south. The rain broke a period of 30 days or more without measurable rain in parts of north-east England, and one of 37 days in the south. From the 23rd to 27th high-pressure areas moved eastward across southern England. Atlantic fronts gave rain in many places, chiefly in the north, but weather remained fine and dry in parts of eastern and southern England. An anticyclone, near the Jutland peninsula, intensified on the 28th and an associated warm southerly airstream over the British Isles maintained dry weather with plentiful sunshine until the end of the month.

Over England and Wales general rainfall was only 10 per cent of the 1916–50 average and the month was easily the driest September since comparable records began in 1870, and probably the driest, according to some estimates, since 1754. Over Scotland, with 36 per cent of the average, the only drier September was in 1894 although September 1933 was as dry. With 45 per cent of the average rainfall it was the driest September in Northern Ireland since 1941.

Parts of East Anglia and southern Devon were rainless throughout the month and less than 5 per cent of the average was recorded over much of the Midlands, East Anglia, southern England and the central and southern Pennines. It was warm and sunny everywhere and very warm in central, southern and south-west England, parts of Wales and in the Glasgow area, where day temperatures were more than 6°F above the average. At many places it was the sunniest September since 1911, and in parts of Cornwall, Devon and Dorset, the sunniest of the century.

Most crops were suffering from the continued dry weather although the ripening of top fruit and tomatoes was hastened by the warmth and sunshine. Growers spent vast sums on irrigation with varying results, but many had to abandon it owing to lack of water. Most brassicas were at a standstill and late sowing of lettuce was in the main a failure. Milk yield suffered owing to lack of pasture but the corn harvest is said to have been the best since the hot summer of 1921 although not since that year have there been so many fires involving farms and crops.

WEATHER OF OCTOBER 1959

The general character of the weather is shown by the following provisional figures:—

	AIR TEMPERATURE			RAINFALL		SUNSHINE
	Highest	Lowest	Difference from average daily mean†	Percentage of average*	No. of days difference from average*	Percentage of average†
	°F.	°F.	°F.	%		%
England and Wales ...	83	23	+4·3	92	−1	139
Scotland	77	25	+4·4	105	−5	128
Northern Ireland ...	72	33	+4·3	122	−3	115

* 1916–1950 † 1921–1950

RAINFALL OF OCTOBER 1959

Great Britain and Northern Ireland

County	Station	In.	*Per cent of Av.	County	Station	In.	*Per cent of Av.
London	Camden Square	2·01	85	*Pemb.*	Maenclochog, Dolwen Br.	10·26	144
Kent	Dover	3·36	101	*Carm.*	Aberporth	6·20	133
,,	Edenbridge, Falconhurst	3·90	117	*Radnor*	Llandrindod Wells	4·75	111
Sussex	Compton, Compton Ho.	3·59	93	*Mont.*	Lake Vyrnwy	8·63	122
,,	Worthing, Beach Ho. Pk.	2·25	76	*Mer.*	Blaenau Festiniog	13·39	106
Hants.	St. Catherine's L'thouse	2·99	88	,,	Aberdovey	5·88	116
,,	Southampton, East Pk.	3·09	93	*Carn.*	Llandudno	3·97	123
,,	South Farnborough	2·39	93	*Angl.*	Llanerchymedd	5·53	121
Herts.	Harpenden, Rothamsted	2·18	83	*I. Man*	Douglas, Borough Cem.	5·05	100
Bucks.	Slough, Upton	2·50	99	*Wigtown*	Newtown Stewart	6·39	117
Oxford	Oxford, Radcliffe	1·93	77	*Dumf.*	Dumfries, Crichton R.I.	4·89	106
N'hants.	Wellingboro' Swanspool	1·73	75	,,	Eskdalemuir Obsy.	6·34	97
Essex	Southend W.W.	1·99	89	*Roxb.*	Crailing	1·66	60
Suffolk	Ipswich, Belstead Hall	1·68	71	*Peebles*	Stobo Castle	4·07	100
,,	Lowestoft Sec. School	2·71	117	*Berwick*	Marchmont House	2·51	77
,,	Bury St. Ed., Westley H.	1·77	73	*E. Loth.*	N. Berwick	1·46	55
Norfolk	Sandringham Ho. Gdns.	2·00	78	*Midl'n.*	Edinburgh, Blackf'd H.	1·66	59
Dorset	Creech Grange	4·56	112	*Lanark*	Hamilton W.W., T'nhill	4·28	97
,,	Beaminster, East St.	3·90	94	*Ayr*	Prestwick	5·61	133
Devon	Teignmouth, Den Gdns.	3·12	96	,,	Glen Afton, Ayr San.	8·57	132
,,	Ilfracombe	6·01	138	*Renfrew*	Greenock, Prospect Hill	7·07	95
,,	Princetown	8·75	97	*Bute*	Rothesay	5·99	90
Cornwall	Bude	4·68	124	*Argyll*	Morven, Drimnin	8·03	108
,,	Penzance	5·19	119	,,	Ardrishaig, Canal Office	...	...
,,	St. Austell	8·17	163	,,	Inveraray Castle	11·06	104
,,	Scilly, St. Marys	4·46	125	,,	Islay, Eallabus	6·94	108
Somerset	Bath	2·82	87	,,	Tiree	5·85	115
,,	Taunton	2·74	90	*Kinross*	Loch Leven Sluice	2·94	76
Glos.	Cirencester	2·16	66	*Fife*	Leuchars Airfield	1·30	46
Salop	Church Stretton	3·58	103	*Perth*	Loch Dhu	8·93	95
,,	Shrewsbury, Monkmore	2·17	82	,,	Crieff, Strathearn Hyd.	3·56	81
Worcs.	Worcester, Red Hill	2·28	99	,,	Pitlochry, Fincastle	5·15	127
Warwick	Birmingham, Edgbaston	3·00	104	*Angus*	Montrose Hospital	3·08	99
Leics.	Thornton Reservoir	2·27	85	*Aberd.*	Braemar	5·09	123
Lincs.	Cranwell Airfield	1·39	64	,,	Dyce, Craibstone	3·94	110
,,	Skegness, Marine Gdns.	1·61	81	,,	New Deer School House	4·32	116
Notts.	Mansfield, Carr Bank	1·95	73	*Moray*	Gordon Castle	3·96	126
Derby	Buxton, Terrace Slopes	4·50	90	*Inverness*	Loch Ness, Garthbeg	4·46	99
Ches.	Bidston Observatory	2·80	94	,,	Fort William	9·92	107
,,	Manchester, Airport	3·01	93	,,	Sky, Duntulm	6·26	104
Lancs.	Stonyhurst College	5·74	108	,,	Benbecula	6·29	123
,,	Squires Gate	3·57	97	*R. & C.*	Fearn, Geanies	2·55	98
Yorks.	Wakefield, Clarence Pk.	1·65	68	,,	Inverbroom, Glackour	8·92	142
,,	Hull, Pearson Park	1·95	82	,,	Loch Duich, Ratagan	11·88	130
,,	Felixkirk, Mt. St. John	1·68	64	,,	Achnashellach	11·51	126
,,	York Museum	1·72	78	,,	Stornoway	5·63	129
,,	Scarborough	1·78	79	*Caith.*	Wick Airfield	4·01	129
,,	Middlesbrough	1·26	53	*Shetland*	Lerwick Observatory	3·81	86
,,	Baldersdale, Hury Res.	3·19	82	*Ferm.*	Belleek	7·85	156
Nor'l'd	Newcastle, Leazes Pk.	1·90	73	*Armagh*	Armagh Observatory	3·92	117
,,	Bellingham, High Green	2·44	70	*Down*	Seaforde	3·92	97
,,	Lilburn Tower Gdns.	2·09	66	*Antrim*	Aldergrove Airfield	4·02	112
Cumb.	Geltsdale	4·47	115	,,	Ballymena, Harryville	5·16	114
,,	Keswick, Derwent Island	8·74	126	*L'derry*	Garvagh, Moneydig	4·89	110
,,	Ravenglass, The Grove	5·81	122	,,	Londonderry, Creggan	4·83	101
Mon.	A'gavenney, Plâs Derwen	3·68	83	*Tyrone*	Omagh, Edenfel	5·64	130
Glam.	Cardiff, Penylan	5·54	123				

* 1916–1950

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