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SNOW SURVEY OF GREAT BRITAIN

Season 1953–54

An annual report of the Snow Survey of Great Britain has been published by the British Glaciological Society in each of the past seven years in its *Journal of Glaciology*. In 1953 the work of the Survey terminated, and the collection of the records was undertaken by the Meteorological Office. The report for 1953–54 which follows has accordingly been prepared in the British Climatology Branch of the Meteorological Office.

As in previous years the basic material for the report has been derived from the returns made by many enthusiastic voluntary observers who have provided, month by month, daily records of snowfall and of any snow-cover within their range of vision. These records relate to a network of land stations distributed over the country, and are augmented by data extracted from the regular monthly returns from official weather stations and from voluntary climatological stations reporting to the Meteorological Office. In addition, information on snowfall around our coasts has again been provided by the returns from lighthouses and lightships, made available by the courtesy of the Elder Brethren of Trinity House and by the Commissioners of Irish Lights, and also by the returns from a number of ships at sea, supplied through the good offices of various shipping companies. Without the co-operation of all those responsible for these voluntary observations it would not have been possible to have prepared this report in anything approaching its present detail.

In general, measurements of snow depth in this report refer to 0900 G.M.T. or thereabouts.

Summary of the 1953–54 season.—The season may be classed as one of less than average snowfall. Data for the ten representative stations* in Great Britain, at altitudes between 400 and 1,200 ft., which have been used for seasonal comparison since the survey of 1946–47 give a mean of 26 days with snow lying at the hour of morning observation. This compares with an average of 34 such days derived from the past seven seasons. In the preceding seven seasons the mean number of days ranged from 13 in 1948–49 and 1949–50 to 66 in the snowy season of 1946–47, showing the great variability of snowfall in the British Isles. The seasonal distribution of snowfall in 1953–54 was in strong contrast to that of 1952–53, when late autumn and early winter were unusually cold and much

* These stations are:—Dalwhinnie, Braemar, West Linton, Eskdalemuir, Huddersfield (Oakes), Buxton, Whipsnade, Little Rissington, Princetown and Rhayader.

FIG. 1—GREAT BRITAIN AND NORTHERN IRELAND

snow fell in the later half of November and middle of December. In the present season the late autumn and early winter were exceptionally mild[1]. In consequence there was remarkably little snow until early January; even on Ben Nevis the snow in December was described as very light and patchy. The latter part of January and the first part of February 1954 were, however, extremely cold. The heaviest snowfalls occurred over western and southern districts of Great Britain on January 25–26 and in the north and east on February 27–28.

Notes on the months.—*September 1953.*—No reports of snow were received and on Ben Nevis snow completely disappeared about the end of the month.

October 1953.—The weather was again mild for the season in Scotland. There was little snow, though sleet showers occurred at Lerwick on the 3rd, Glenlivet on the 14th and 15th, and at Leverburgh, Isle of Harris, on the 26th–29th; very slight falls of snow were recorded on Ben Nevis on the 14th, 25th and 27th. Snow lay on some of the mountains in central and western Scotland mainly at heights above 2,500 ft. between the 27th and 31st and on Ben Nevis also on the 25th.

November 1953.—The month was unusually mild throughout the country and there was very little snow. Snow or sleet showers occurred at times at a few places, mainly during the first week and on the 30th. Snow lay on the mountains in central and western Scotland on some mornings during the first part of the month and on the 30th; on Ben Nevis it lay throughout the month, generally at a height above 3,000 ft. At Leverburgh, the observer noted that outdoor daffodils were showing.

December 1953 was also exceedingly mild. The extreme mildness of the month can be deduced from the following quotations by observers. Mr. A. F. Airey of Windermere writes: "Prunus trees were in blossom at Ambleside and Grasmere" and Mr. L. H. Lomas of Leverburgh, Isle of Harris, reported: "Daffodils showing five months earlier than usual". Slight snow or sleet fell at times in the later part of the month, chiefly on the 24th and 25th and in the south-east on the 31st. On the 24th drifts of 2 ft. were observed at 2,000 ft. on the eastern faces of the Braes of Balquhidder. Snow lay on some Scottish mountains and on Sca Fell, Westmorland, from the 24th or 25th to the 31st and locally at times during the first part of the month, particularly on the 4th and 5th. On Ben Nevis it lay throughout the month above 3,500 ft. but it was very light and patchy. No snow-cover was reported on the Welsh mountains during the months October to December inclusive.

January 1954.—The first ten days were mainly cold, and a notably cold spell with severe frost occurred from the 23rd to the 31st. Snow or sleet was widespread on the 6th and 7th and rather widespread around the 13th. Heavy snow fell in western districts of Great Britain and much of southern England on the 25th–26th, and mainly small amounts fell daily thereafter until the end of the month. At Clun, Shropshire, the average depth was 13 in. on the 26th–28th and 14 in. on the 29th–31st; at Evancoyd, Radnorshire, 12 in. fell on the night of the 25th–26th and the average depth was 12 in. on the 26th–28th; at Meggernie Castle Gardens in Glen Lyon, Perthshire, the average daily depth after the 26th was 11 in.; at Bwlchgwyn snow lay 12 in. deep on the 26th and there were drifts 6 ft. deep on the 28th; on the Brecon Beacons there were drifts up to 6 ft. on the 29th–31st.

February 1954.—At some places in the south temperature remained at 32°F. or below continuously from the evening of January 29 to the morning of February 7. Thus the snow which fell at the end of January lay on the ground during the first part of February, and mainly slight snow fell at times also during this period. The strong north-easterly winds in southern England caused drifting and some villages were isolated, notably in Kent; on the 1st drifts up to 7 ft. were reported at Throwley, near Faversham, and at Biddenden drifts up to 3 ft. on the 3rd persisted for a week. Considerable snow fell in the north and east from the 6th or 7th to the 10th and, with strong winds, in the northern Pennines on the 12th–13th. On the hills around Balquhidder, Perthshire, snow was 15 in. deep without drifting at 1,200 ft. on the 9th. Drifts up to 5 ft. were recorded at Moor House, Westmorland, and at Alston, Cumberland, on the 10th. Snow fell again during the last few days and was heavy locally at times; it was fairly widespread on the 28th. At Moor House the average depth was 9 in. on the 25th and 12 in. on the 26th–28th.

March 1954.—The weather was unsettled and changeable, with a very cold wintry spell during the first few days. On the 1st snow lay on high ground from the snowfall at the end of February, and more snow fell in some parts during the first three or four days. On the hills in the neighbourhood of Plymouth the snowfall above 400 ft. on the 1st was the heaviest of the winter; depths of 6 in. were reported around Princetown. In north-west England and north Wales heavy snow occurred on the 2nd accompanied by strong winds; the observer at Bwlchgwyn (1,267 ft.) recorded: "the blizzard of the 2nd was the worst of the winter with excessive drifting" and roads were blocked by 2200. At Fairburn (500 ft.), Ross and Cromarty, the average depth on the 4th was 5 in. drifting to 5 ft. and at Glenferness (700 ft.), Nairnshire, there were drifts up to 8 ft. on the 4th. The weather was warm from about the 10th to 12th, but a marked fall of temperature occurred on the 13th and some snow fell locally on the 13th and 14th. Scattered wintry showers occurred at times during the last week.

April 1954.—April was dry generally, and notably sunny. Mean temperature was below the average in England and Wales but somewhat above the average in Scotland. The nights were unusually cold; ground frosts were frequent and air frost was severe locally at times and occurred more often than is usual in April. There was little snow, though snow or sleet showers occurred at times; they were widespread between the 4th and 6th, and occurred locally in western districts of England and Wales on the 1st, at a few scattered places on the 12th and 13th, and in many parts of Scotland on the 30th. There were few days with snow cover even on the hills except on those in the neighbourhood of Glen Lyon during the first half of the month and on the 30th. Ben Nevis was snow-covered throughout the month at heights above 2,500 ft., and down to below 1,500 ft. on the 30th.

May 1954.—The first week and the period 14th–24th were mainly cool, while it was warm on the whole from about the 10th to 12th and 26th to 31st, though the last days were cooler in eastern districts. Snow or sleet showers occurred on the 1st–6th (particularly on the 1st–3rd), and locally in north-west England on the 22nd. On the slopes of the Dunstable Downs, the snow was fairly heavy from 1700 to 1800 on the 2nd.

Duration of snow-cover on British mountains.—The mean number of days of snow-cover at 2,500 ft. on four mountain groups used as indices was 71 as compared with an average of 83 for the past seven seasons. The stations used were Glenbrittle (Cuillin Hills), Meggernie (Glen Lyon), Capel Curig (Snowdonia) and Tairbull (Brecon Beacons). Diagrams showing the distribution of snow-cover relative to height for 10 stations are given in Fig. 2.

Harris, in the Outer Hebrides, reported snow-cover on some days in each month from November to May. The maximum number of days, 21, occurred in February at heights above 1,500 ft. The snow-line reached sea level on seven days during the season.

The Cuillins of Skye had some cover on one day in October and in each month from December to April; at 3,500 ft. there was continuous cover from January 13 to April 3. The snow-line reached sea level on eight days in February and three days at the beginning of March.

The peaks around Glen Lyon had snow-cover on October 28 and in each month from November to May; it lay continuously down to 3,000 ft. from January 21 to April 11, and at station level (760 ft.) from January 25 to February 16, and from February 24 to March 7.

The Paps of Jura were snow free until January 5 and from March 16 to April 30, but on May 1 snow lay down to sea level for the one day. At 2,500 ft. it lay continuously from January 26 to February 9 and February 16 to March 9.

Ben Nevis was snow free until October 24. The summit was under continuous cover from October 26 until January 9 and from January 12 until the end of the season. In the period up to January 9, however, snow-cover came down to 2,000 ft. on only 10 days. Between January 13 and March 7 there was cover at station level (30 ft.) on 11 days.

The peaks near Capel Curig had no snow-cover until January 6, but they were under cover on some days in each month during the rest of the season. Snow-cover came down to station level (700 ft.) from January 26 to February 6 and from February 28 to March 5. Cover was observed on three days in early April and on the first two days of May.

In south Snowdonia there was no snow-cover until January 7 and then it only lasted two days; there was continuous cover at 2,500 ft. from January 26 to February 8 and from February 25 to March 5. Snow-cover was observed on three days in early April but none from April 7 to the end of the season.

The Brecon Beacons were snow free until January 6. Cover was continuous at 2,500 ft. from January 26 to March 28. It came down to station level (660 ft.) from January 26 to February 9, on February 19 and 20 and on six days in the first half of March. There were two days with snow-cover in the first week in April and three in early May.

Cross Fell was snow free until December 24 when snow persisted for three days. The summit was covered continuously from January 29 to February 20 and February 24 to March 11. Snow-cover was observed on 2 days in April and on 5 days in May, the latest date being May 22. Snow was observed below 1,000 ft. on January 14, continuously from January 29 to February 12 and February 25 to March 7, and on March 22.

Helvellyn was snow free until January 7 apart from some cover on December 25. The summit was covered continuously from January 26 to 31 and February 4 to March 9. Snow-cover was observed also on April 5 and May 6 and 22. Snow lay at station level (520 ft.) on January 26 and 31, February 4, 7–12 and 26–28 and March 3.

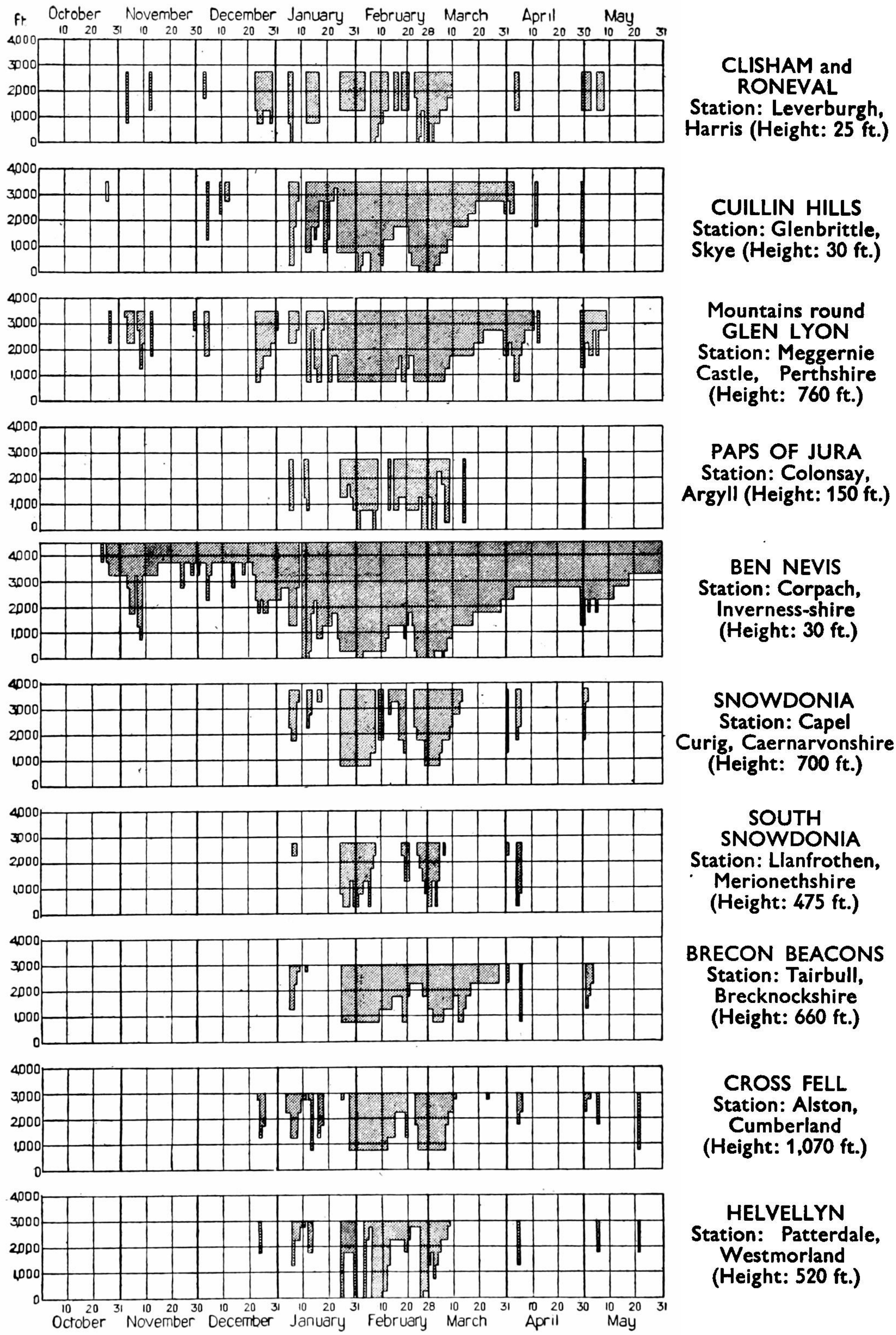

FIG. 2—DISTRIBUTION OF SNOW-COVER IN RELATION TO HEIGHT

Curves showing the total seasonal duration at six stations are drawn in Fig. 3; 200 days' cover was exceeded on Ben Nevis above 3,500 ft. and 100 days' cover was exceeded on the mountains about Glen Lyon above 2,500 ft.

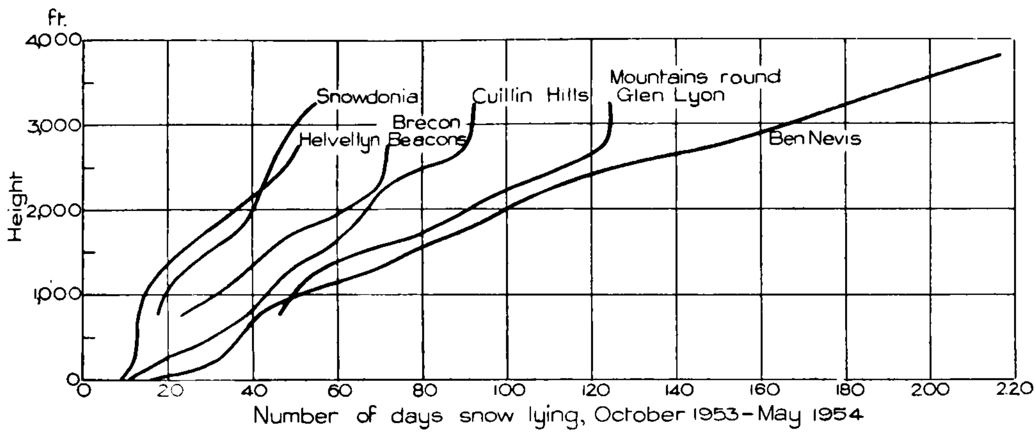

FIG. 3—SEASONAL DURATION OF SNOW-COVER

Snowfall in British coastal waters.—Returns were received for the 1953–54 season from 91 lighthouses and lightships round the coasts of England and Wales and from 60 lighthouses and lightships round the Irish coast; 18 returns were received from merchant ships. The earliest snowfall at sea was reported by the Morecambe Bay light-vessel on December 13. Most of the snowfall reported at sea occurred between the beginning of January and the end of the first week in March. The number of days with snow during the season ranged from only 2 at the Scarweather light-vessel in the Bristol Channel and at the Eddystone, Bishop Rock and Wolf Rock lighthouses to 24 at the Cromer and Inner Dowsing light-vessels. The last report of snowfall at sea came from the M.V. *Lochiel* who experienced scattered snow showers on May 1 when she was on passage from Port Askaig, Islay, to Loch Tarbert, Jura.

REFERENCE

1. LEWIS, L. F.; Exceptional weather of November 1953 to early February 1954. *Met. Mag., London*, **83**, 1954, p. 143.

PROBABILITY PAPER AND ITS APPLICATIONS IN UPPER AIR CLIMATOLOGY

By N. GOLDIE, B.Sc.

The traditional picture of a tropopause surface sloping steeply in middle latitudes but extending continuously from pole to equator has tended in late years to be replaced, for each hemisphere, by that of two tropopause surfaces of which both the upper, characteristic of the tropics, and the lower, characteristic of poleward regions, extend into middle latitudes so that there is a zone of overlap between latitudes 30° and 40°. Loewe and Radok[1] show that this is consistent with tropopause observations over Australia. Between 32°S. and 38°S. in winter, they find the frequency distributions of height of tropopause to be compounded each of two normal distributions with means in the neighbourhood of 10 and of 15 Km., while to the south (at Macquarie Island, 54°S.) the 10-Km. distribution prevails and to the north (at stations north of 27°S.) the 15-Km. distribution. Their analyses were performed by means of probability paper.

This type of graph paper was used in the Upper Air Climatology Branch of the Meteorological Office in an early attempt to sort out some of the irregularities found in the tropopause pressures reported at British stations overseas. Shortly after the present article was first circulated[2], more complete investigations were made by the Meteorological Office into the incidence and true nature of the tropopause (both single and multiple), and definitions of stratosphere and troposphere were proposed which would remove ambiguities earlier inherent in the determination of tropopauses.

The present article is concerned primarily with outlining the principles underlying the construction and use of probability paper, the brief discussion of the tropopause over Habbaniya being included mainly in illustration of a somewhat unusual application of probability paper. Reference is made also to its use in estimating the likelihood of strong winds on aircraft routes.

The symbols used in this description of probability paper include the following:—

X = a variate, plotted as abscissa
x = the departure of any specified value of X from the mean of the frequency distribution of X
σ = the standard deviation of X
N = the number of observations in the frequency distribution
t = a standardized variate, i.e. x/σ
P = the probability integral.

Probability scale.—Probability paper may be obtained from most printing firms who specialize in the production of different types of graph paper. It has been widely used in America where it was applied to a meteorological problem as early as 1924, when W. R. Gregg and J. P. van Zandt[3] demonstrated by means of probability paper the normality of a frequency distribution of westerly wind components at 1,500 ft. over the United States.

The use of probability paper for the examination of frequency distributions is analogous to the use of semi-logarithmic paper in examining a relationship of the form $Y = ab^X$ between the two variates X and Y, which gives a straight line when Y on the logarithmic scale is plotted against X on the linear scale. Similarly, a normal frequency distribution gives a straight line on probability paper, the logarithmic scale of semi-logarithmic paper being replaced by a "probability" scale in which the ordinate Y is the cumulative frequency of X.

On semi-logarithmic paper, the scale of Y is linear with respect to log Y; on probability paper, the probability scale is linear with respect to the standardized normal deviate, i.e. with respect to t when t is distributed normally. It is easily seen that this arrangement of scale results in a straight line when a normal distribution is plotted, for

$$t = \frac{x}{\sigma} = \frac{1}{\sigma} X + \text{a constant.}$$

The markings on the probability scale give values of $100P$ where P is the "probability integral" defined by the expression

$$P = \frac{1}{(2\pi)^{\frac{1}{2}}} \int_{-\infty}^{t} \exp\left(-t^2/2\right).dt.$$

Corresponding values of $100P$ and $t = x/\sigma$ are given in Table I.

TABLE I—CORRESPONDING VALUES OF t AND $100P$ FOR A NORMAL DISTRIBUTION

(*a*) For evenly-spaced values of t

t:	−3·0	−2·5	−2·0	−1·5	−1·0	−0·5	0·0
$100P$:	0·13	0·62	2·3	6·7	15·9	30·9	50·0
t:	0·0	0·5	1·0	1·5	2·0	2·5	3·0
$100P$:	50·0	69·1	84·1	93·3	97·7	99·38	99·87

(*b*) For standard values of $100P$

$100P$:	0·1	0·2	1·0	2·0	5·0	10·0	20·0	30·0	40·0	50·0
t:	−3·09	−2·88	−2·33	−2·05	−1·64	−1·28	−0·84	−0·52	−0·25	0·00
$100P$:	50·0	60·0	70·0	80·0	90·0	95·0	98·0	99·0	99·8	99·9
t:	0·00	0·25	0·52	0·84	1·28	1·64	2·05	2·33	2·88	3·09

A more detailed table of $100P$ in terms of t is given by Yule and Kendall[4], and t in terms of $100P$ by Fisher and Yates[5] under the heading "Probits".

Plotting a frequency distribution.—In plotting a frequency distribution on probability paper, the ordinates are determined by numbering the observations in order of magnitude and multiplying the numbers so obtained by $100/N$ to convert them to percentages. In place of the usual ordinal numbers, 1, 2, 3, . . . N, it is preferable to adopt the series $\frac{1}{2}$, $1\frac{1}{2}$, $2\frac{1}{2}$, . . . , $(N - \frac{1}{2})$. The ordinates are then symmetrical about the 50-per-cent. line, and the mean as well as the standard deviation of a distribution which is normal can be estimated directly from the graph; also, this avoids the difficulty of plotting a probability number of 100 per cent. which, to be correct, would have to be placed at an infinite distance from the 50-per-cent. line.

The plotting of grouped observations is described in an appendix.

Estimating the mean and standard deviation.—In order to estimate graphically the mean and standard deviation of a normal, or almost normal, distribution, a straight line is fitted by eye to the plotted points. The mean is then read off, being the abscissa of the intersection of this line with the 50-per-cent. line. For example, in Fig. 6 the mean for curve (*b*) is 83 mb. and for curve (*c*) 212 mb. while for the curve in Fig. 7 the mean is 85 mb.

The standard deviation is given by the slope of the fitted line. With the aid of Table I, σ can be determined from the difference between almost any two values of X; but the most accurate method is to read off values corresponding to the probability numbers, $100P = 6 \cdot 7$ and $100P = 93 \cdot 3$, and to divide the difference between them by 3. As a check, it may be verified that the result is the difference between the mean and the value of X corresponding to $100P = 84 \cdot 1$.

Effect of combining two normal frequency distributions.—The straight lines (*a*) and (*c*) of Fig. 1 show on probability paper the plot of two normal frequency distributions with the same standard deviation (10 units) but different means (25 and 55 units). If in each there are 25 observations which fit exactly the straight line, they will have the following values:—

Probability number ...	2	6	10	14	...	50	...	86	90	94	98
Curve (*a*)	4·5	9·5	12·2	14·2	...	25	...	35·8	37·8	40·5	45·5
Curve (*c*)	34·5	39·5	42·2	44·2	...	55	...	65·8	67·8	70·5	75·5

Plotting the whole 50 observations as one distribution yields the curve ABCD shown at (*b*). The circles are observations comprising distribution (*a*) and the crosses those comprising distribution (*c*). The normal distribution with the

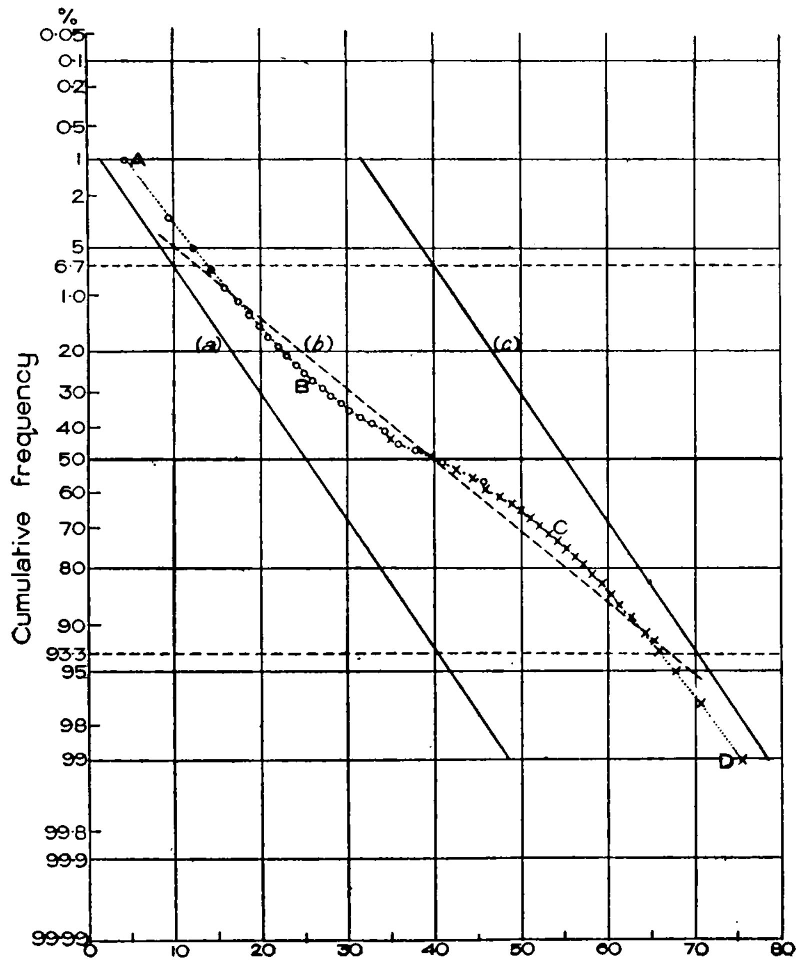

FIG. 1—COMBINATION OF NORMAL DISTRIBUTIONS WITH DIFFERENT MEANS

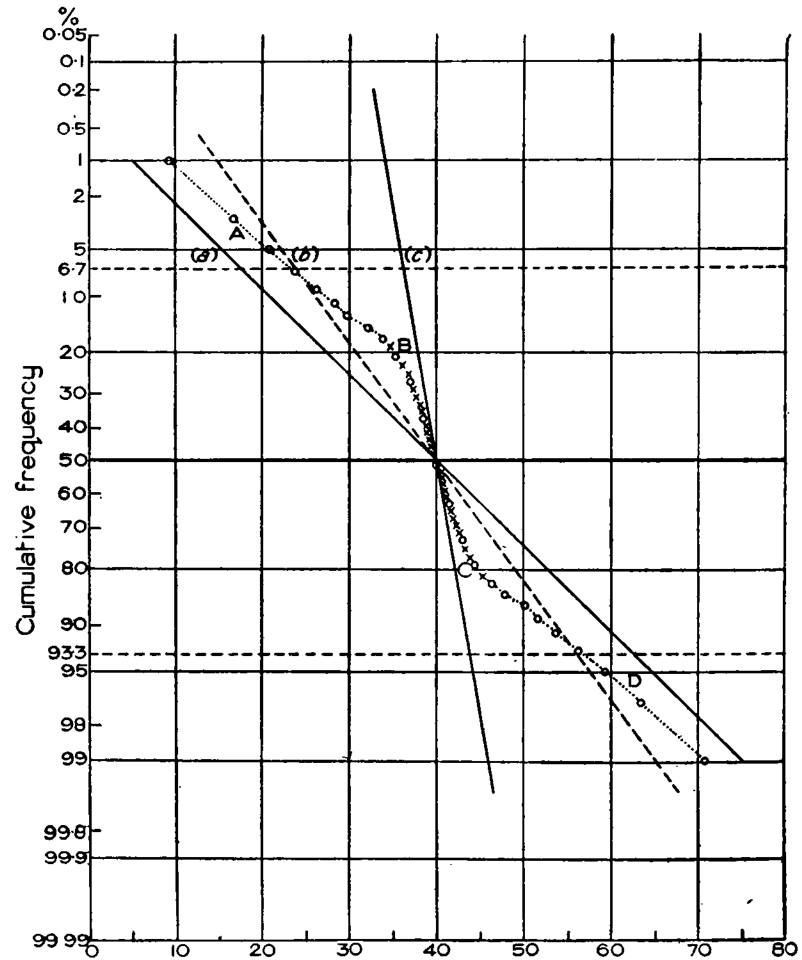

FIG. 2—COMBINATION OF NORMAL DISTRIBUTIONS WITH DIFFERENT STANDARD DEVIATIONS

same mean and standard deviation as the composite distribution is shown by a broken line; mean = 40; σ = 18. It will be seen that between A and B and between C and D the slope of the curve is steeper than that of the broken line whereas between B and C it is less steep. In other words, there are more observations between $0 \cdot 8\sigma$ and $2 \cdot 0\sigma$ on either side of the mean than would be expected in a normal distribution and fewer within $0 \cdot 8\sigma$ of the mean. This type of distribution which has an excess of medium-sized deviations from the mean and a deficit of small deviations is termed platykurtic (flat-topped).

Fig. 2 shows, in similar fashion, the effect of combining two normal distributions with the same mean (40 units) and different standard deviations (15 and 2·5 units). In this, the composite curve shows an excess of small deviations (within $0 \cdot 4\sigma$ of the mean) and a deficit of medium-sized deviations (between $0 \cdot 4\sigma$ and about $2 \cdot 0\sigma$ from the mean). This type is leptokurtic (humped).

Meteorological examples.—Examples of nearly normal, platykurtic and leptokurtic frequency distributions of meteorological elements are shown in Figs. 3, 4 and 5. In each of Figs. 4 and 5, the equivalent normal distribution is shown by a broken line.

The nearly normal distribution of upper air temperatures at 300 mb. over Downham Market, shown in Fig. 3, has a slight tendency to positive skewness since the curve indicated by the crosses is slightly steeper than the straight line at the top of the diagram and less steep at the foot, showing that observations of temperature between −70° and −60°F. are bunched more closely together, but that temperatures above −40°F. are further apart, i.e. tend to be more extreme, than would be expected if the distribution were normal. The platykurtic distribution in Fig. 4 of temperature at 200 mb. also shows lack of symmetry. The curve in Fig. 5 is based on data given by Hesselberg[6]. These data were also used for illustration in the "Handbook of statistical methods in meteorology"[7]; markedly leptokurtic distributions of meteorological elements appear to be somewhat rare. It may well be that each frequency distribution in meteorology can quite often be represented by a combination of two normal distributions with different standard deviations and approximately the same mean; but, unless the discrepancy in the standard deviations is very large, the compound distribution is not readily distinguished from one that is genuinely normal.

Analysis of tropopause pressures.—During the period January 1948 to November 1950 radio-sonde staff at British stations were required to report for each ascent only one tropopause; towards the end of 1950, those at British stations overseas were instructed to note also on their returns any second tropopause observed, and to punch, on the appropriate Hollerith card, the lower of the two tropopauses.

When the observations for 1948 to 1950 were summarized, remarkable inconsistencies appeared in the monthly means of the tropopause pressures. At Bahrein (26° 16′N. 50° 37′E.) for instance in December 1950 the tropopause pressure, which for 35 months had been in the neighbourhood of 75–100 mb., increased suddenly to about 180 mb. It was evident that before December 1950 the upper tropopause had been reported almost invariably; but, in accordance with the new instruction, the lower tropopause now appeared in the Hollerith tabulations. This was confirmed by plotting the December data, as summarized, on probability paper. The resulting curve was conclusively

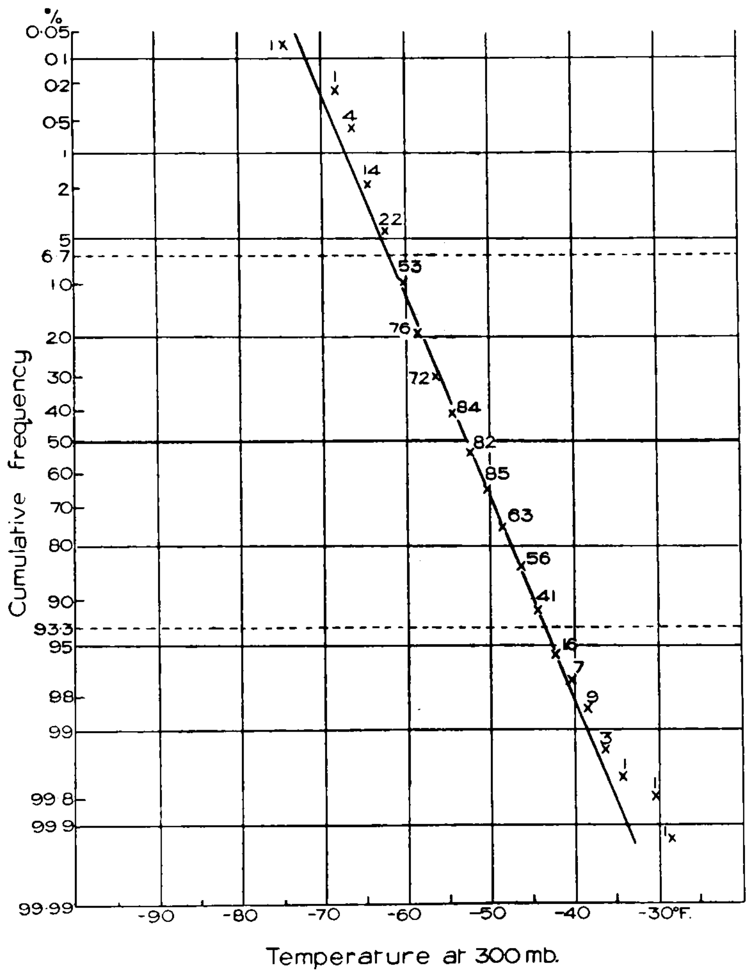

FIG. 3—TEMPERATURE AT 300 MB. OVER DOWNHAM MARKET, APRIL 1946–51

Distribution almost normal. The figures shown against the plotted points give the numbers of observations.

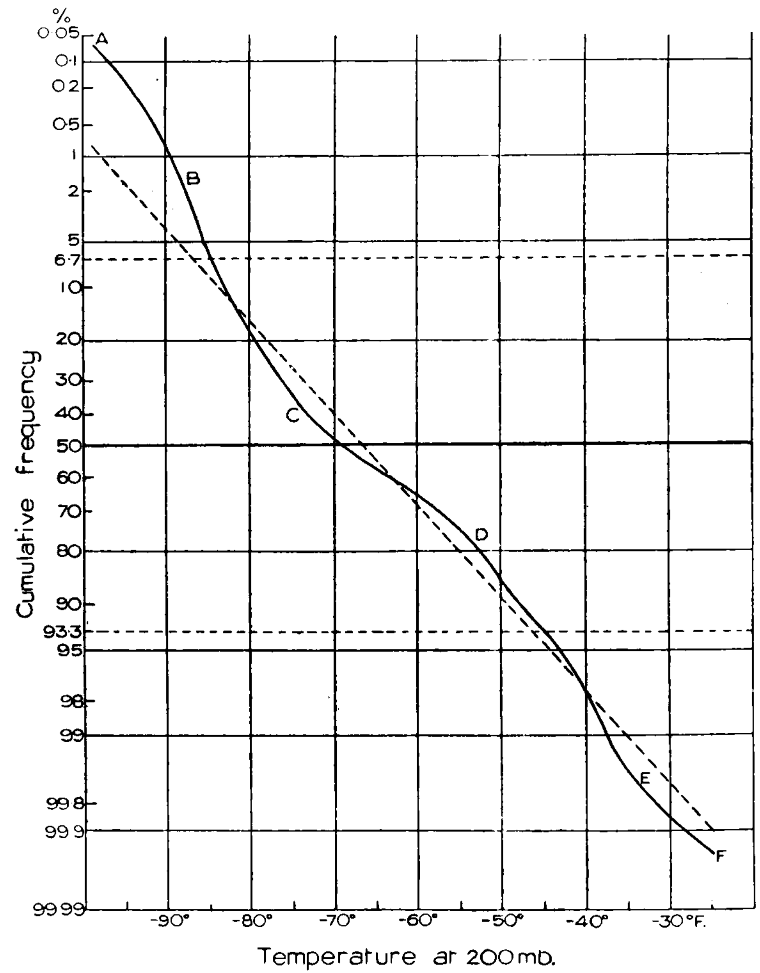

FIG. 4—TEMPERATURE AT 200 MB. OVER DOWNHAM MARKET, APRIL 1946–51

Platykurtic distribution, i.e. excess of medium-sized deviations from the mean.

platykurtic and the aggregate distribution split readily into two normal distributions with means at 99 mb. and 187 mb., all but two observations of the 187-mb. distribution (lower tropopause) having been recorded in December 1950 and only three observations from this month being included in the 99-mb. distribution (upper tropopause). At Habbaniya (33° 22'N. 43° 34'E.) similar discrepancies were found, e.g. in the first half of 1949 considerably higher tropopauses were recorded than in the same months of 1948 and 1950. A cursory examination of the discontinuities of temperature in 1949 suggested that lower tropopauses also were present.

The present brief examination of the tropopause over Habbaniya consisted of an analysis of the tropopause pressures recorded in 1948–50 for the mid-season months, January, April, July and October. The probability graphs for April and July are shown in curve (*a*) of Fig. 6 and in Fig. 7. They are plotted from observations grouped into 10-mb. classes. The curve for July in Fig. 7 is the more striking: there is no doubt whatsoever as to the normality of this distribution. The curve for April, Fig. 6, is definitely platykurtic. It approximates to two straight lines with a short transition region between. The numbers of observations in the different frequency classes, shown by small figures against the plotted points, are seen to fall off in the transition region. A break was made where the observations were fewest, as indicated in Fig. 6, and each of the portions so obtained was replotted, individual observations being used for the upper tropopauses, for these numbered only 27. Replotting resulted in curves (*b*) and (*c*). It is seen that the two component distributions are roughly normal, departures from the normal distribution (full line) being sufficiently small to be attributable to the scantiness of the data.

The analyses made for January and October 1948–50 showed similar features to that for April. A summary for all four months is given in Table II; apart from those for the April lower tropopause, the means and standard deviations were estimated from the graphs by the method described in this article. The lower tropopause seems to be entirely absent in July; a fact which was confirmed by examination of data for July 1951.

It may be concluded that, for the greater part of the year, Habbaniya is situated in the region of overlap of the tropical and polar tropopauses, the latter being the more frequent in January and April and the former in October —provided, of course, that this concept of a discontinuous tropopause surface is true. In July, the tropical régime prevails.

TABLE II—TROPOPAUSES RECORDED AT HABBANIYA, 1948–50

Observations were made at 0200 and 1400 G.M.T.; only one tropopause, either upper or lower, was recorded for each observational hour each day.

	Upper tropopause				Lower tropopause			
	Mean pressure	Standard deviation	No. of obs.	Period	Mean pressure	Standard deviation	No. of obs.	Period
	mb.	mb.			mb.	mb.		
January	100	10	23	1949, 1950	224	45	82	1948, 1950
April	83	13	27	1949	212	33	117	1948, 1950
July	85	15	118	1948–50	...	...	...	...
October	106	19	106	1948–50	181	11	26	mainly 1950

Plot of probability graph from mean and standard deviation.— Another use of probability paper in upper air work is in estimating the magnitude of equivalent headwinds or tailwinds likely to be equalled or exceeded on

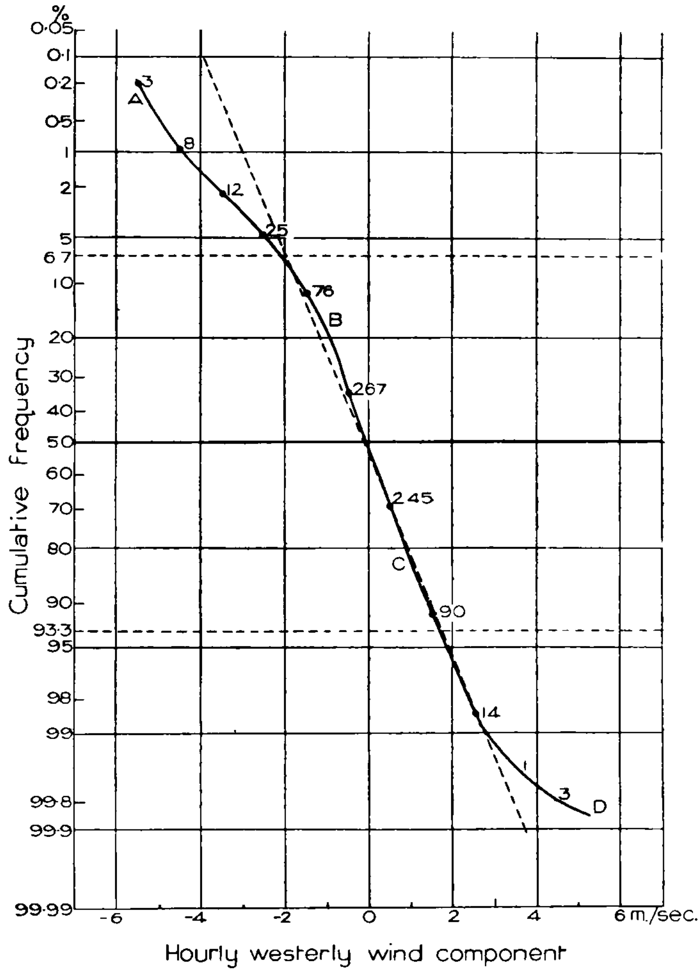

FIG. 5—HOURLY WESTERLY WIND COMPONENTS AT AAS, NORWAY, 59° 40′N. 10° 46′E., JANUARY 1929
Leptokurtic distribution, i.e. excess of small and large deviations from the mean.

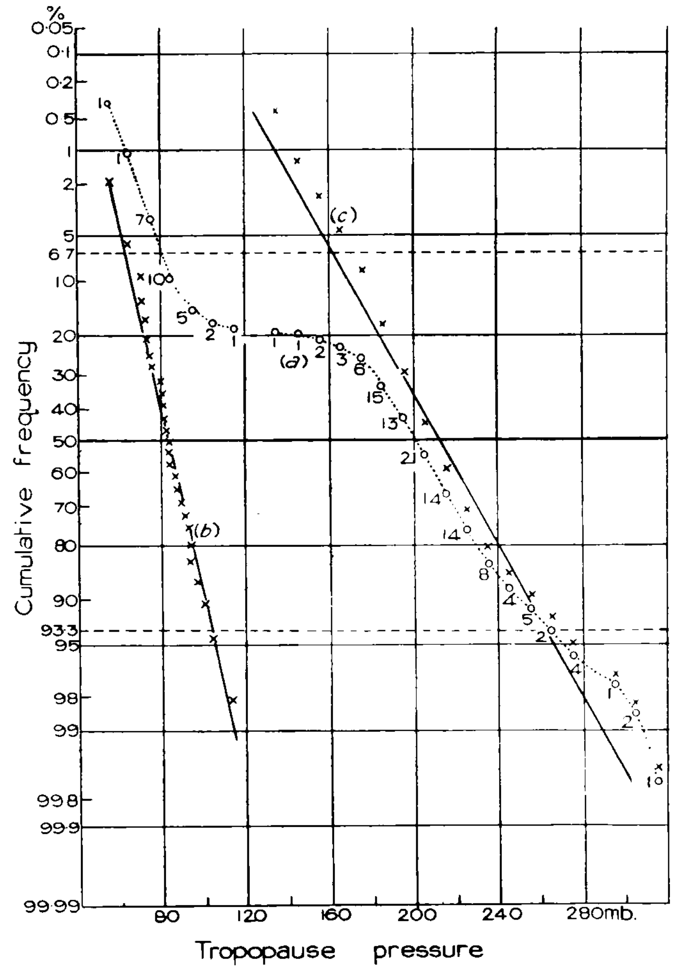

FIG. 6—TROPOPAUSE PRESSURES RECORDED AT HABBANIYA IN APRIL 1948–50
(*a*) Total recorded distribution
(*b*) and (*c*) Replot

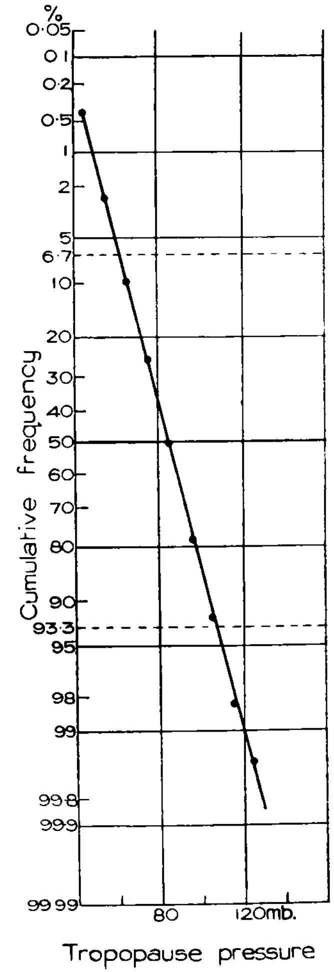

FIG. 7—TROPOPAUSE PRESSURES RECORDED AT HABBANIYA, JULY 1948–50

a specified number of occasions over an aircraft route. From the vector mean and standard vector deviation of winds at places along the route, values can be computed[8] for the mean and standard deviation of the expected distribution of headwinds and tailwinds in the direction required, tailwinds being treated as negative values of headwinds. The mean and standard deviation are plotted on probability paper in the following manner:—

A scale of wind speeds is chosen such that about six times the standard deviation will fit into the width (i.e. along the linear scale) of the graph paper, the mean value being central or nearly so.

The values, Mean $-\frac{3}{2}$ (standard deviation), Mean, and Mean $+\frac{3}{2}$ (standard deviation) are then marked on the linear scale and points are plotted with these as abscissae and the probability numbers, 6·7, 50·0 and 93·3 respectively, as ordinates.

A straight line is drawn through the three points (any two of them of course will suffice, but a third makes the setting of the ruler more certain).

The straight line shows the required normal frequency distribution and from it can be read off wind speeds corresponding to any percentile, e.g. the headwind expected to be equalled or exceeded once in ten occasions will be the abscissa corresponding to the ordinate 90·0 on the probability scale.

The method of plotting just described applies to any normal distribution of which the mean and standard deviation are known. It is not necessary, however, to know the mean and standard deviation specifically; any two parameters (e.g. two percentile values) can be plotted to fix the straight line on probability paper.

Summary.—Probability paper may generally be said to have three main uses:—

(i) It provides a fairly quick method of determining whether or not a given frequency distribution is approximately normal. Also, if the distribution is not normal, the type of non-normality may often be assessed from the probability graph.

(ii) From the plot of a normal distribution, the values of mean and standard deviation can very rapidly be determined without the necessity of going back to the original figures.

(iii) When any two parameters of a normal distribution are known, other parameters are found merely by drawing a straight line and reading off on one or other scale of co-ordinates.

As described in this article, probability paper has been used also to separate out two normal components of a compound frequency distribution; but this has been in instances where the overlap was extremely small. Analysis of compound distributions into normal components is not generally possible by means of probability paper.

Acknowledgement.—The author is indebted to Miss E. E. Austin for her helpful criticism of an earlier draft of this article.

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Appendix

Method of plotting grouped observations on probability paper

In plotting grouped observations on probability paper, it is convenient to plot the probability number associated with the middle observation of each class against the middle point of the range covered by that class. Table III shows the tabulation for the April tropopause pressures plotted in Fig. 6, curve (*a*).

TABLE III—METHOD OF PLOTTING GROUPED OBSERVATIONS ON PROBABILITY PAPER

Pressure (1)	Frequency (2)	Cumulative frequency (3)	Mid value of pressure range (4)	Probability number (5)
mb.			mb.	%
50–9	1	½	54½	0·35
60–9	1	1½	64½	1·04
70–9	7	5½	74½	3·8
80–9	10	14	84½	9·7
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
290–9	1	140½	294½	97·5
300–9	2	142	304½	98·6
310–9	1	143½	314½	99·7

Column (1) shows the range of pressure in each class and column (2) the frequency. The cumulative frequency in column (3) is the number of observations from the beginning of the table up to the middle observation of the class considered, the middle observation contributing ½. The simplest method of computing the cumulative frequency corresponding to any specified class is to add the cumulative frequency assigned to the preceding class to the mean of the actual frequencies of these two classes in column (2). For the class 50–9 mb., by taking the frequencies and cumulative frequencies of preceding classes to be zero, the cumulative frequency is found to be

$$0 + \tfrac{1}{2}(0 + 1) = \tfrac{1}{2}$$

for the next class,

$$\tfrac{1}{2} + \tfrac{1}{2}(1 + 1) = 1\tfrac{1}{2}$$

and for the next,

$$1\tfrac{1}{2} + \tfrac{1}{2}(1 + 7) = 5\tfrac{1}{2}$$

and so on throughout the column.

Column (4) of Table III gives the central pressure value of each class; and column (5) gives the probability number, obtained by multiplying the cumulative frequency, column (3), by $100/N$. In this example, $N = 144$. In plotting, the figures of column (4) are the abscissae, those of column (5) the ordinates, of the plotted points. The ordinates are, of course, plotted on the probability scale in order that a normal distribution may be immediately apparent as a straight line.

WORLD GLIDING CHAMPIONSHIPS 1954

By C. E. WALLINGTON, M.Sc.

Few sports are so dependent on the weather as that of gliding and soaring, and, at the request of the British Gliding Association, a temporary meteorological office was set up at the 1954 World Gliding Championships held at Camphill, Derbyshire, from July 21 until August 4, 1954 for the purpose of providing the competition organizers and pilots with necessary information.

For the purpose of supplying the two Meteorological Office forecasters, Mr. C. E. Wallington and Mr. G. A. Marshall, with adequate basic data,

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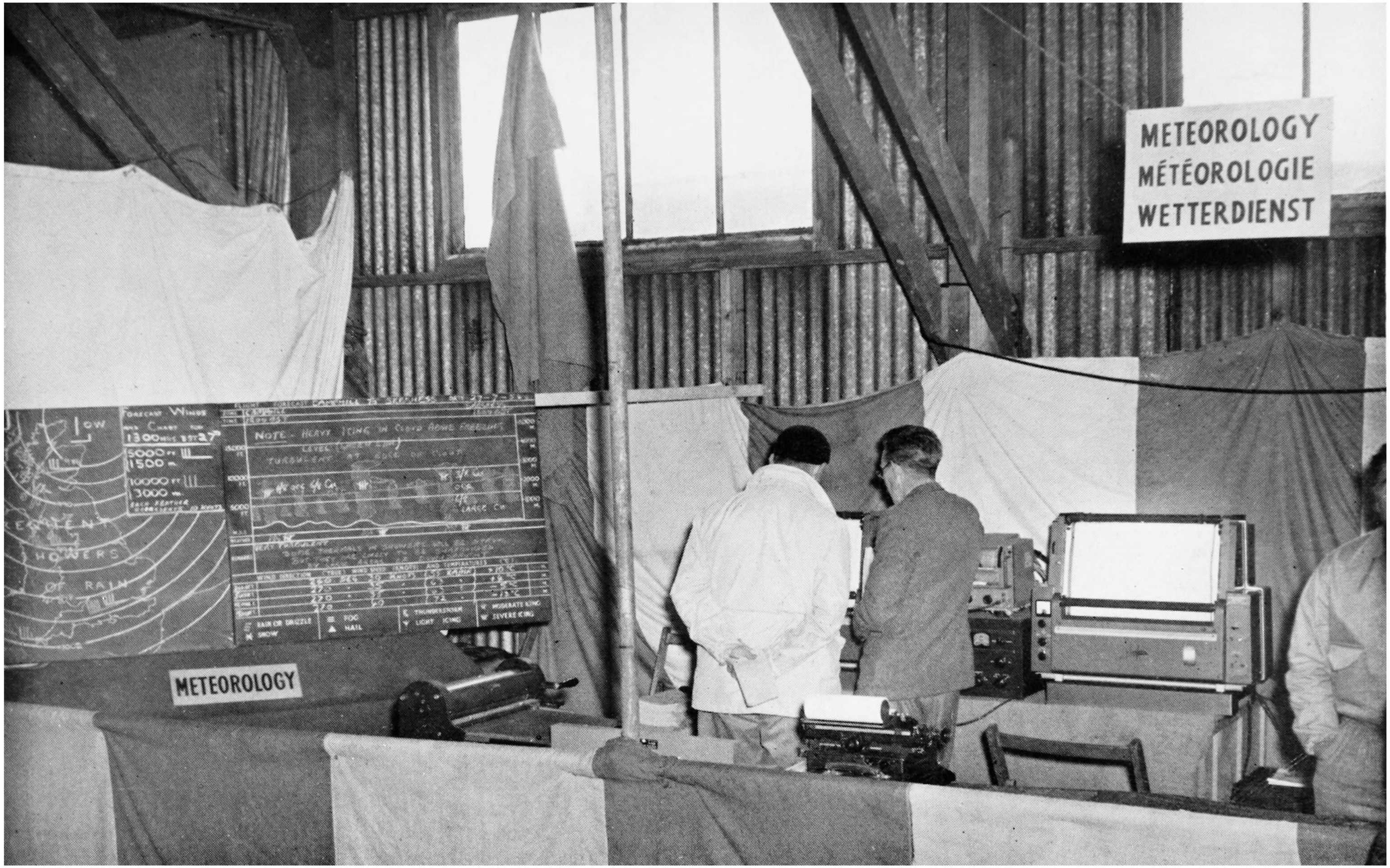
METEOROLOGICAL SECTION AT CAMPHILL, DERBYSHIRE, FOR THE WORLD GLIDING CHAMPIONSHIPS

In the background is the briefing board with the forecast for July 27; on the right-hand side are the facsimile recorders on which data were received

Reproduced by courtesy of Muirhead & Co. Ltd

METEOROLOGICAL SECTION AT CAMPHILL, DERBYSHIRE

Mr. W. Main, of the Meteorological Communications Centre, Dunstable, is tuning in the recorder whilst Mr. J. Knight is watching a 1 : 10,000,000 synoptic chart being recorded (see p. 368).



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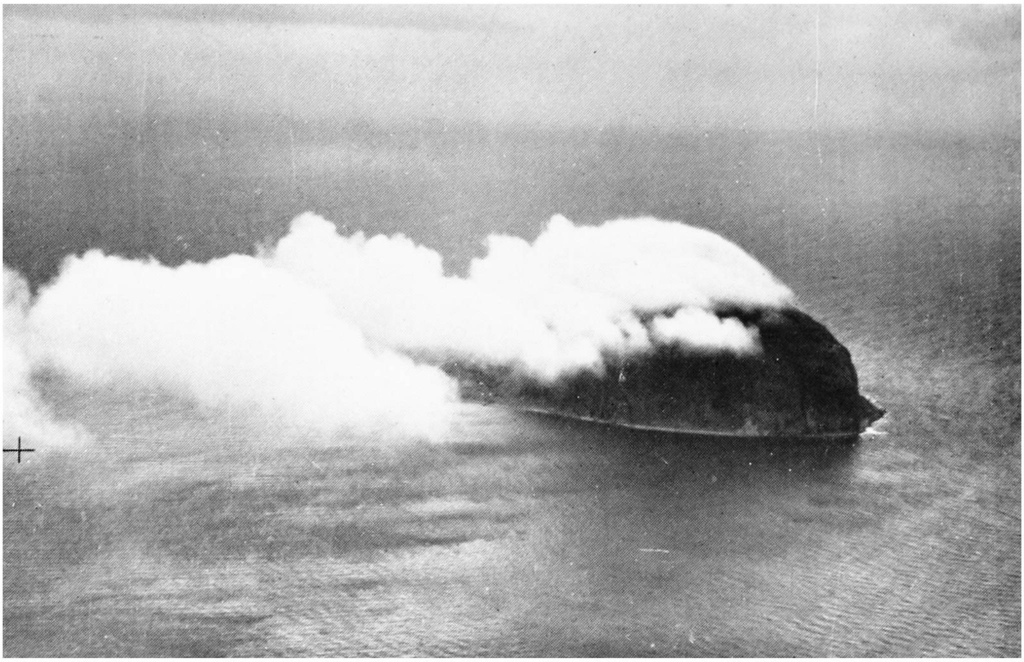
METEOROLOGICAL SECTION AT CAMPHILL, DERBYSHIRE

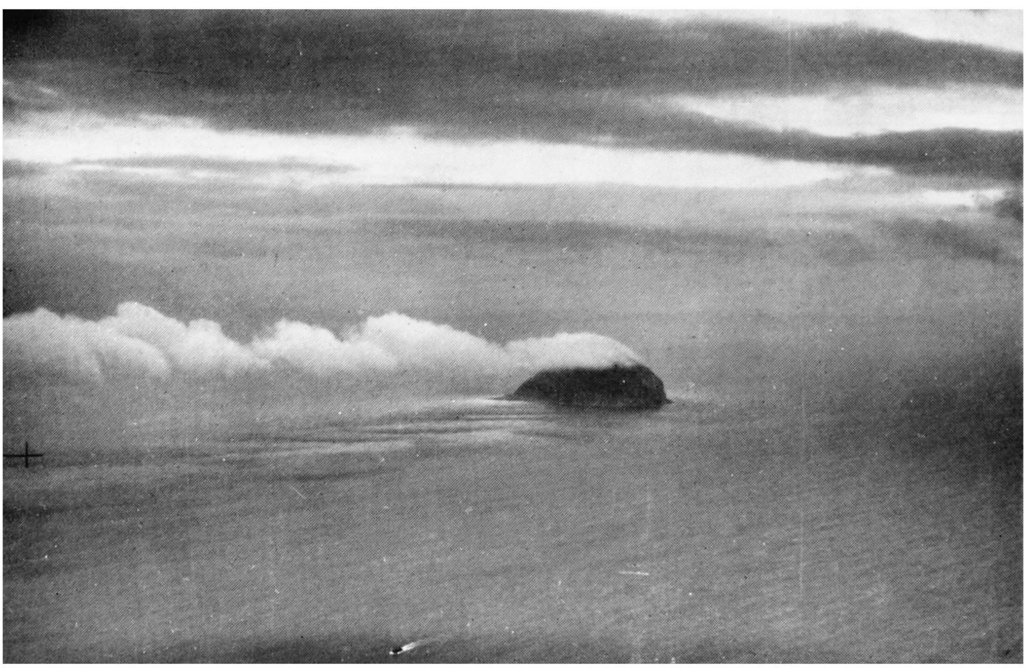
An official of the World Gliding Championships having the weather explained to him as the chart is received by facsimile. The international character of the contest can be seen by the three-language notice in the background (see p. 368).

To face p. 369]



Photograph by R.A.F.

0810 G.M.T.



Photograph by R.A.F.

0813 G.M.T.

OROGRAPHIC CLOUD OVER AILSA CRAIG

These photographs were taken from a height of 2,500 ft. on March 23, 1940, when a moist air stream was blowing up the Firth of Clyde. It is clear that the eddies formed in the lee of the rock are of the same dimensions as the rock itself. In these conditions, with a rather stable lapse rate (as was shown by the morning ascent at Aldergrove), the air fails to circumnavigate an obstacle of the comparatively small horizontal dimensions of Ailsa Craig, but ascends over its summit (1,114 ft.).

recording equipment was installed to receive facsimile charts radioed from Dunstable. Initially, radio reception was frequently subject to interference from cars, tractors and other sources and the charts suffered some mutilation. This difficulty was overcome, however, with the co-operation of British Petroleum and Shell Services Ltd. in the supply of a quantity of suppressors and the individual efforts of Messrs. J. Knight and W. Main of the Meteorological Communications Centre, Dunstable, who, in the course of the meeting, fitted no less than 69 suppressors to the offending vehicles and equipment.

Far from being a mere substitute for the usual supply of teleprinter data this facsimile service with its prompt and copious supply of charts and tephigrams was practically indispensable in the circumstances. The plotting of charts on the spot would have been at least unpleasant in the damp and often cold atmosphere, but the hourly British Isles facsimile charts were usually available about 70 min. after the time of observations. Furthermore, the fortnight's excessive rainfall would almost certainly have rendered teleprinter landlines unserviceable, as were the telephone lines on many occasions.

Information on local upper air conditions was provided by a Spitfire THUM aircraft which, from its base at Woodvale, made an ascent at 0830 G.M.T. whenever possible over Camphill, instead of over Worcester, its normal position for ascent.

There was, therefore, an ample supply of meteorological raw material on which to base the short-range, but extremely detailed, forecasts required by championships organizers and pilots.

Dissemination of meteorological advice to the 43 competing pilots usually began with a general briefing at which a broad outline of the appropriate forecast would be presented with the help of English, French, Spanish and German speaking interpreters to the 19 teams of different nationalities. Immediately after that each pilot would discuss the details personally with the forecasters, occasional language difficulties being simplified by the use of blackboard sketches to show the synoptic situation and a pictorial version of the forecast (see photograph facing p. 368). Nine of the visiting teams brought their own meteorologists with them to act as tactical advisers.

Assessment of up-currents associated with convection cloud and local topography forms the principal element of a soaring forecast but such up-currents seldom exceeded 10 ft./sec. throughout the fortnight's meeting, and even these weak currents could not be fully exploited in the Camphill locality. All too often the site, situated at 1,300 ft. above sea level midway between Sheffield and Buxton, was befogged with orographic cloud in the persistently moist westerly air streams while the longed-for cumulus developed only a few miles away to the east. When, at last, vigorous-looking instability cloud did appear overhead it was accompanied by a gale-force wind blowing up and over the steep 450-ft. escarpment forming the long western boundary of the 1,400 yd. × 400 yd. flying field; for a whole day, although it might have been just possible for sailplanes to take off, the pronounced eddying of the surface wind would have made landing at Camphill extremely dangerous.

No records were broken and no spectacular results were achieved. But before a gliding championship can be declared valid a certain minimum amount and type of flying must be performed, and the fact that this was accomplished in such difficult conditions is a tribute to the high standard of sailplane flying today. In the circumstances some flights could be considered remarkable, especially those by Philip Wills of Great Britain in his single-seat Sky sailplane and the Yugoslav, Zvonimir Rain, with his radio operator in the two seat Kosava aircraft. Flying over the top of almost unbroken cloud, both of these pilots used a series of standing waves to out-distance their competitors. Wills landed near Cranwell while the Yugoslavs flew on to Marham, 106 miles from Camphill. But for many pilots who vainly struggled until dusk to reach these elusive waves it was yet another disappointing day. Fortunately the depressing effect of the weather was admirably off-set by the excellent social spirit which pervaded Camphill throughout the championships.

OFFICIAL PUBLICATIONS

The following publications have recently been issued:—

Handbook of weather messages. 2nd edition. Parts II and III.

Changes which have been agreed internationally are being made in most of the surface and upper air codes to be used in synoptic reports and aeronautical forecasts with effect from January 1, 1955. These are the first major changes of this nature to be made for six years. Some modifications in weather recording and the preparation of synoptic charts will be introduced on the same date. The revised "Handbook of weather messages" constitutes a complete guide to internationally and regionally approved practices on these matters. A feature of the new edition is that pages are in loose-leaf form to facilitate the entry of amendments which are issued periodically.

Part II contains the codes and specifications used in the compilation of surface reports, upper air reports, reports from aircraft, forecast codes and upper air analyses. The book contains 28 forms of coded messages, 121 code specifications and more than 225 different combinations of letters to describe the various elements dealt with in the codes. Part III gives detailed information concerning the entry of the readings into the registers, coding the information for transmission, decoding messages received from other sources and finally plotting the information on synoptic charts.

A new edition of Part I containing particulars of meteorological reports, forecasts, warnings etc. issued by radio in the United Kingdom and from certain centres overseas is in course of preparation.

Instructions for the preparation of weather maps.

The symbols used for plotting weather maps have been necessarily changed as a result of the new synoptic codes which are being introduced, with international agreement, on January 1, 1955. The full codes and specifications relating to surface observations from land stations and ships are reproduced in an appendix to this booklet.

Amateur meteorologists, who receive the GFA morse broadcasts from Dunstable and plot their own weather charts, no less than aircraft pilots and navigators who are required to read weather charts plotted in the conventional symbols as part of their professional qualifications, will find the information contained in this new edition of "Instructions for the preparation of weather maps" essential.

A copy of this new edition will be supplied as part of the present edition of "Meteorology for aviators".

INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

General Assembly, Rome, 1954

The International Union of Geodesy and Geophysics (U.G.G.I.) holds a general assembly once every three years, the meeting place changing from one assembly to the next. The tenth assembly was held at Rome from September 14 to 25, 1954, by invitation of the Italian National Committee. The meetings of the assembly itself were preceded by a conference on atmospheric radiation organized by the Radiation Commission of the Association of Meteorology and by a symposium on ozone organized by the Ozone Commission.

Some 900 delegates from more than 40 countries attended the meetings which were held in one of the buildings of the "Exposition Universelle de Rome", known locally as E.U.R. The erection of a group of large buildings on this extensive site outside Rome was commenced before the war for an exhibition which, but for the war, would have been held in 1942. Some of the buildings have not yet been completed, but the "Palais des Congres" provided an admirable meeting place for the Assembly of U.G.G.I. A large number of lecture rooms of various sizes were available and an exhibition of geodetic and geophysical equipment was staged in two large halls within the building. This exhibition continued throughout the assembly and manufacturers and organizations from all over Europe were represented.

The International Union of Geodesy and Geophysics comprises seven distinct associations each concerned with one aspect of the physics of the earth, the oceans or the atmosphere. These are:—

International Association of Geodesy
International Association of Seismology and Physics of the Interior of the Earth
International Association of Meteorology
International Association of Magnetism and Atmospheric Electricity
International Association of Oceanography
International Association of Volcanology
International Association of Hydrology.

During the course of the assembly it was decided that electrical phenomena of the atmosphere below the ionosphere fall within the domain of the International Association of Meteorology and a consequent change of title of the International Association of Magnetism and Atmospheric Electricity was agreed.

The formal opening meeting took place on the morning of September 14 when the delegates were welcomed on behalf of the Italian Government and addressed by Prof. Sydney Chapman, president of U.G.G.I. over the past three years.

Most of the time of the assembly was taken up by meetings of the separate associations at which scientific papers were presented and discussed, and at which the progress in particular fields of geophysics was reviewed. The individual associations met concurrently, and, indeed, the number of papers presented was such that within one association more than one meeting might be in progress at one time.

Scientific meetings of the Association of Meteorology opened on September 15 with the presidential address by Prof. K. R. Ramanathan on "Atmospheric ozone and the general circulation of the atmosphere". The meetings which followed covered a wide range of subjects: synoptic meteorology, cloud physics, climatology, ozone, dynamical meteorology, the upper atmosphere, radiation and instruments. In all more than 70 scientific papers were presented to the Association of Meteorology alone, and it is impossible to review them individually.

Perhaps the two symposia which showed the most coherent and systematic progress in meteorological research were those devoted to meridional large-scale phenomena and to numerical methods in dynamic and synoptic meteorology. From the former meeting one gained the impression that from painstaking work, particularly in America and Australia, a consistent statistical picture of the general circulation is being built up, not only in terms of the mean values of wind, temperature, etc., but also in terms of the statistical properties of its large-scale eddies and the heat and momentum transport which results from them. Although the authorities differ in the details of their interpretation a reasonably coherent picture is beginning to emerge.

The colloquium on numerical methods ranged widely over the use of numerical techniques in meteorology from predicting the motion of depressions to predicting the dispersal of smoke, but main interest centred on the problems of predicting the changes in the synoptic chart. Very similar degrees of success are being achieved by experimenters in America, Sweden, Germany and the United Kingdom. Interest was stimulated by the results reported from Sweden in which a barotropic model had been used to compute a forecast chart for 72 hr. ahead, and had achieved a correlation between observed and predicted change of more than $+0\cdot7$. R. Fjörtoft claimed similar success in calculations by graphical techniques over 72-hr. periods.

A symposium of storm surges held jointly between the Associations of Meteorology and Oceanography was also of considerable interest to the meteorologist, and showed the systematic research effort which is being expended on this problem.

A discussion of some interest was held regarding proposals by Dr. T. E. W. Schumann of South Africa for a planned programme of international meteorological research. Although there was considerable agreement as to the way that meteorological research should be encouraged to go, it was agreed that no formal international planning of the lines of research was needed or desirable. However, a motion proposed by Prof. Rossby calling attention to the significance and interest of the mineral constituents of rain-water was adopted.

The formal closing session of U.G.G.I. took place on Saturday September 25. It was then announced that the President for the coming three years will be Prof. K. R. Ramanathan of India. The next assembly will be held by invitation in Argentina. The President of the Association of Meteorology for the next three years will be Prof. C.-G. Rossby, Sweden, and the Secretary Dr. R. C. Sutcliffe, United Kingdom. Following the assembly, meetings continued in Rome for the planning of the scientific work of the International Geophysical Year which is to be held in 1957–58.

The success of such large assemblies as the three-yearly meetings of U.G.G.I. is not to be measured only by the papers which are read and the formal discussions which take place. Probably more important are the informal contacts which take place outside the conference rooms. Scientists from different countries get to know one another as individuals, they exchange plans and little bits of specialist information and experience which are unlikely ever to be published.

Such friendly contacts and meetings were greatly facilitated at Rome by the arrangements made by the Italian Organization Committee for the entertainment of the delegates and their families. Delegates were received at the Capitol on September 22, and on September 24 they were granted an audience by the Pope who addressed them for 16 min. in French. On these and on the less formal excursions a very friendly spirit existed among the delegates, and those who attended are greatly indebted to their Italian hosts for these opportunities to get together with workers in similar fields from other lands.

J. S. SAWYER

BRITISH ASSOCIATION

Oxford meeting 1954—Symposium on weather forecasting*

The discussion on weather forecasting arranged by Section A (Mathematics and Physics), as might be expected after a disastrous summer with weather more than usually a matter of public concern, drew a large gathering to the Sheldonian Theatre on September 6. The chair was taken by Prof. E. H. Neville and later by Sir Harold Spencer Jones who introduced the guest speaker from Sweden, Prof. C.-G. Rossby, now Director of the Meteorological Institute of the University of Stockholm but equally renowned for his work in the United States, having held chairs in both Chicago and the Massachusetts Institute of Technology.

In opening the discussion with a paper on weather forecasting as a problem in physics, Dr. R. C. Sutcliffe first remarked that weather forecasting was something more than the science on which it rested, it was a scientific profession with some hundreds of practitioners issuing some thousands of forecasts daily for a wide variety of purposes. In a short paper it would be possible only to indicate the general nature of the scientific problems, but in weather forecasting where it was impossible for every interested member of the public to be given personal advice on his own particular problem it was particularly important that the client should have some understanding of the subject.

The problems of weather forecasting might be regarded as falling within the scope of hydrodynamics, but the methods which had been successful in other fields had so far contributed relatively little to the practical problems of weather prediction as they arise from day to day. This was because the problems were extremely complex being concerned with non-steady and turbulent motions in the compressible fluid of a heat engine working against friction. The system was not even closed and the composition of the fluid was continuously changing by evaporation, condensation and precipitation. Meteorology had therefore to be studied as a science in its own right and predictions about the atmosphere must depend on its observed structure and behaviour.

Dr. Sutcliffe was mainly concerned to emphasize the different scales of atmospheric systems. On any one day the circulation of the atmosphere differed widely from the long-term climatological mean, and examples from surface and upper air weather maps of the northern hemisphere were used to show how depressions and anticyclones frequently formed over periods of one or two days. These systems were well understood scientifically and, as Prof. Rossby would show, could be predicted by hydrodynamical theory but they were essentially a form of large-scale turbulence and after a period of one or two days predictions became very uncertain.

Variability was present on many smaller scales—frontal systems, vertical convective systems through to variations on the scale of kilometres and metres. Much of this variability was beyond the reach of regular observations and could only be treated in statistical terms.

* Reprinted from *Nature* by courtesy of the Editors.

Weather forecasting could be regarded as based on five considerations:—

(i) The change in the large-scale synoptic situation. This could give for one or two days ahead the broad character of the weather and wind.

(ii) The effects of fronts—allowing fairly accurate timing of rain areas and major changes of wind, temperature, etc. for periods of some 12 hr. ahead.

(iii) The convective properties of the air masses—permitting statistical-probability statements on showers, thunderstorms, convective cloud, visibility, etc.

(iv) Diurnal changes—these were major considerations for temperature, humidity, convective phenomena and visibility.

(v) Topographical effects—these introduce many local differences in weather.

Although formally these aspects may be considered separately they are not independent.

Owing to the rapidity with which changes take place and to the element of dynamical instability which enters into the developments, there seemed no present prospect of eliminating uncertainty from weather forecasts. Dr. Sutcliffe was optimistic about dynamical meteorology which had made great progress in very recent years but he was not optimistic about persuading the atmosphere to behave in a more orderly way.

Mr. V. R. Coles spoke of the work of a practising forecaster. He depended in the first place on obtaining adequate observations and the absence of reporting ships in some areas, for example south of Greenland and even in the Bay of Biscay, was often a serious handicap. The stationary ocean weather ships in the Atlantic were a great boon. The erratic behaviour of depressions was illustrated by examples where extrapolation would give a good prediction and others where it failed completely. In recent years much attention had been given to upper air conditions and relationships between the consideration of the upper thickness or thermal patterns and the development and movement of surface depressions were established. Mr. Coles illustrated the success of this method with an example of the rapid formation of a new anticyclone which had been very satisfactorily predicted. The methods of extrapolation, the use of tendencies and the indications from the upper air were not always consistent and Mr. Coles thought that if much greater accuracy in forecasting was to come it would probably be by the use of objective methods of calculation using electronic methods.

The first two speakers had been mainly concerned with forecasts for some 24 hr. ahead made familiar to the public by press and broadcasting and it fell to Dr. J. M. Stagg to consider the possibilities of prediction for longer periods. Experience had shown that attempts to extend the forecasts to a few days ahead by the methods discussed by earlier speakers met with little success; the accuracy falls away very quickly after the first 30–36 hr. But nevertheless it was a commonplace observation that weather has a "moodiness" and generally bright or dull or rainy weather may persist for long periods. Meteorologists have therefore looked for something in the atmosphere more enduring than the simple depressions and anticyclones.

Dr. Stagg referred first to certain purely empirical methods to which much attention had been given. The field of surface pressure had been elaborately analysed for periodicities and correlated with measures of geomagnetic and solar activity, and although much had been learned about the modes of oscillation of our atmosphere little of prediction value had resulted. A phenomenon referred to as symmetry in the pressure-time curve had been discovered in Germany; variations of pressure were shown to repeat in reverse order after a point in time known as a "symmetry point". But tests made in England were no more successful than others based on extrapolations of pressure trends; by the time a trend had become established it was already on the way to another rhythm or pattern. Methods of correlation, although they had had some success in India for monsoon prediction, generally failed in a similar way. It was not surprising if the atmospheric machine produced good relationships for a time in a particular area as these would reflect the mode of circulation during the period, but if the mode changed so would the correlations and their prediction value might well be slight.

Dr. Stagg saw more of scientific interest in the dynamical-synoptic studies using mean weather charts for periods of days. In the United States the Weather Bureau had introduced forecasts for five days and more recently for 30 days ahead on the basis of continuity in the evolution of mean upper air charts over these periods. The methods had apparently had a measure of success but were still mainly empirical, depending largely on the extrapolation of trends which may suddenly change for no known reason.

In Russia most attention had been given to the movements of anticyclones as the more enduring features of the synoptic patterns, and Dr. Stagg thought it was no coincidence that it was in the great continental areas that long-range forecasting was established. Over the British Isles we were next door to one of the world's worst cockpits of weather disturbances and even a slight error in predicting the mean tracks of depressions could make a forecast completely wrong for the whole country. Dr. Stagg stressed the need for physical understanding of the processes and referred to research going on in the Meteorological Office, but he had in mind a remark made by Sir Gilbert Walker, speaking to the Association 21 years ago: "Though the prestige of a meteorological service may be raised for a year or two by the issue of longer-range forecasts, the harm done to the science will inevitably outweigh the good if the prophecies are found unreliable".

Prof. Rossby introduced the subject of "numerical weather forecasting" by referring again to the broad spectrum of frequencies in atmospheric disturbances which had been the theme of Dr. Sutcliffe's paper. "Weather", in the sense of clouds and rainfall, was produced mainly by the smaller-scale disturbances which had relatively large vertical components of motion. The largest-scale motions, with dimensions of some 5,000 Km., were necessarily quasi-horizontal and it was these motions which had now been shown to be amenable to direct calculation with useful accuracy. The calculations will not produce a detailed weather forecast but they may still prove to be of much assistance to the forecaster by keeping him on the correct broad lines over periods of one or two days.

The conception of forecasting by calculation on the basis of the physical equations originated in England with L. F. Richardson some 30 years ago but the ideas were at that time quite premature as there was no practicable way of carrying out the heavy computations. It was not until 1947 that the subject was taken up seriously at the Institute of Advanced Studies in Princeton, and since then there had been rapid progress on a research basis not only in America but also in England where the work of Sawyer and Bushby was outstanding. In Sweden, with its present limited facilities for electronic computing, Dr. Rossby had confined attention to the simplest model of large-scale atmospheric behaviour but expected to be in a position to introduce more elaborate and realistic calculations in the near future. The basic idea was put very simply. It had been shown that the vorticity (about the vertical axis) of the mean motion of the atmosphere was nearly a conservative property. It could therefore be advected with the mean motion. But by integration, with known boundary conditions, the motion itself could be calculated from the vorticity field so that, using a step-by-step method, it was possible to begin with the present known motion, determine the new field of vorticity for say one hour ahead by advection, compute the new field of motion by integration and so continue indefinitely until such time as accumulated errors rendered the calculations worthless. Mathematical refinements had improved on this simple scheme but the principle remained the same.

Prof. Rossby remarked that "a weather forecast was a rather perishable commodity which must be marketed quickly". Only electronic methods could reduce the time of calculation to anything reasonable as even in his present simple model 10^7 operations were needed to produce a 24-hr. prediction. But it now seemed that the time spent in calculation would not be the most serious item. Much more time was spent in making, transmitting and collecting the observations from the large area involved (some 6 hr.) and in plotting and analysing the charts (some 3 hr.). Attention would need to be given to these factors and already objective analysis and diagrammatic recording were being studied.

To show once more that the computations could deal only with the broad synoptic situation and not with the details of weather, Prof. Rossby showed a diagram illustrating the distortion which may take place in a layer of fluid over a period of a day or two. Beginning as a chequered square of some 500-Km, side, the "fluid element" altered shape by hydrodynamical "deformation" as though it were a handkerchief flourished in the magician's hand, with all pattern becoming confused in the folds. To analyse such motion in the practical case would require the number of observations to be increased by one or two orders of magnitude.

It was regrettable that time did not permit of general discussion after the papers but perhaps the mistake had been in making the subject so broad. Weather forecasting is concerned to some extent with almost the whole science of meteorology and any one of the four papers could have provided the basis for a profitable morning's symposium.

INTERNATIONAL SYMPOSIUM ON EXPERIMENTAL METEOROLOGY

Zurich, October 4–6, 1954

The Swiss Federal Commission for the Study of Hail Formation and Prevention organized an International Symposium on Experimental Meteorology which took place under the presidency of Prof. Dr. R. Sanger at the Swiss Federal Institute of Technology in Zurich during October 4–6, 1954. The symposium, which was arranged with characteristic Swiss hospitality, included visits to Swiss research stations and was attended by representatives of many different countries. Lectures were given by delegates from Switzerland, France, Italy, Germany, Sweden, Japan, the United States, and the United Kingdom. Other sessions were devoted to open discussions of cloud physics and weather modification problems. It is possible in this note to give only a brief summary mentioning some of the striking new facts and experimental methods described in the subsequent lectures. It is planned however to publish in the near future all the papers presented in a special issue of the *Archiv fur Meteorologie, Geophysik und Bioklimatologie.*

Following the address of welcome by the President, who described the attempts being made in Switzerland to prevent hail and their great economic importance, the scope of the symposium was reviewed in opening speeches by H. Dessens of the Observatoire du Puy-de-Dôme, Clermont-Ferrand and B. J. Mason of the Imperial College of Science, London. The latter presented a broad survey of our present knowledge of natural-precipitation processes including the action of both the Bergeron and the coalescence mechanisms, while the former considered various theories concerning artificial nucleation of clouds. It was evident at this stage that, although our understanding of natural rainfall processes has increased considerably in the last few years, much more information is required before we can hope to be in a position to modify the weather in a scientific manner. There are many problems to be solved in the laboratory and also in the field concerning, for example, the conditions which produce inactivation of silver iodide as a freezing nucleus, the regions in which there is a scarcity of natural freezing nuclei in the free atmosphere, whether over-seeding is possible, the respective importance and rates of action of the Bergeron and coalescence processes in different clouds, the importance of splintering in crystallization processes and chain reactions in coalescence processes, to mention only a few.

The papers on laboratory work included Dr. W. Rau's investigations of the spectrum of freezing nuclei in which it was found that they have three maxima around $-4°$C., $-11°$C. and $-19°$C., respectively. The first maximum is most marked in polar air masses which suggests that the earliest acting nuclei have a maritime origin. Dr. Rau has also repeated his previous experiments in which he supercooled water droplets to about $-70°$C., below which cubic ice crystal modifications were observed. Both the observation of this high degree of supercooling and that of freezing nuclei at temperatures near freezing point provide new data and aroused considerable discussion. Another interesting paper in this section was that by G. Soulage who described the detailed characteristics and shapes of some natural freezing nuclei he had isolated, while L. Facy described how the process of vapour transfer during evaporation or condensation of droplets can be observed directly, and gave details of the mechanical operation of these processes. Dr. O. Vittori then described new chromographic techniques for the detection of the chemical nature of aerosols. These are based on the microscopic observation of Liesegang rings formed by precipitates when salts dissolved in gelatine react with the aerosol. This technique is already being applied successfully to identification of aerosols sampled on the ground and in flight.

American flight observations for cloud physics researches were described by Dr. H. R. Byers. He showed how cumulus in semitropical maritime areas differs from that in continental temperate latitudes. The former is characterized by slow up-draught speeds and rain when the cloud does not extend to the freezing level, while the latter has vigorous up-draughts and requires a considerable depth before precipitation can commence.

New measurements of large salt nuclei concentrations and their relations to air trajectories at various heights over the United States were presented, and evidence given that the coalescence mechanism is also important in temperate regions. This finding was supported by R. J. Murgatroyd who described cloud-physics investigations made over England by the Meteorological Research Flight and gave details of the instrumental techniques at present in use. Dr. E. M. Fournier d'Albe describing measurements of large salt nuclei over Pakistan and the variation in their concentration with distance from the sea also emphasized the importance of the coalescence mechanism in all clouds of base temperature more than 10°C. (which includes most of the British Isles and Europe in summer). It appears that in Pakistan the nuclei concentration well inland is not sufficient to account for the rainfall observed, and that multiple fragmentation with a chain reaction must be an important factor in producing heavy rainfall there. Considerable information on the question of nuclei distribution in relation to its sources was also given in a paper by Prof. C.-G. Rossby who presented charts of the distribution of elements brought down by rainfall in Sweden. Sodium, potassium and the chlorides for instance are found to have their greatest concentration near the sea, ammonium near agricultural regions, calcium rather a constant distribution, etc. Other papers in this section included a contribution by Dr. M. Bossolasco on the relation of temperature to solid precipitation (values of $-4°$C., $-11°$C., and $-19°$C. being significant, in agreement with the laboratory studies of freezing-nuclei spectra quoted above).

Although the symposium was very successful in producing an up-to-date resumé of the work being carried out in various countries and an exchange of ideas and information between the workers involved it did not result in any new ideas in the problem of hail prevention, which is of considerable importance in Switzerland. It is to be expected however that the new work now being started there, which includes field experiments and also the construction of a wind tunnel to investigate hail formation, will result in important progress in this problem, and all meteorologists will join in wishing our Swiss colleagues every success in their new ventures.

R. J. MURGATROYD

LETTER TO THE EDITOR

Definition of dry and wet periods

The present definitions of droughts, wet spells, and rain spells may serve certain statistical ends but from most points of view they seem quite inadequate. Using Alston, Cumberland, as an illustration it is unsatisfactory that a place with almost 50 in. of rain a year cannot claim to have had a wet spell since January 1948, and, in fact, only 7 wet spells within the 26 yr. of observations. This may satisfy official tastes but it is not a representative picture of conditions as they exist.

Examination of the records shows clearly the gaps which have been left because of the insufficient number of categories into which to place certain periods of dry and wet weather. For example, the exceptionally wet November and December of 1951 which gave the greatest aggregate for two consecutive months for the entire 26 yr. (i.e. slightly over 20 in.) gave neither a wet nor a rain spell; 47 days received 0·01 in. or more of rain, 41 had 0·04 in. or more, and 6 had over 1 in. of rain. Between November 1 and November 21 there were 20 rain-days and 19 wet-days but "trace" appeared against the 13th so that officially the period must be regarded as normal. Surely precipitation of this order deserves some special mark of distinction.

This kind of event might be claimed to be analogous to a record of 0·99 in. in the rain-gauge which is so very near to 1 in. that there is a sense of disappointment when it must be ignored as a very wet day. However the case is not comparable because the fraction 0·01 in. required to change 0·99 in. into 1 in. is so very much smaller than that required to make 14 days of wet weather into the 15 necessary to make a wet spell.

From the statistical point of view definitions must be fixed and adhered to, but the present system seems over-simplified. The term "partial drought" (29 days with a mean daily rainfall not exceeding 0·01 in.) is helpful for dry periods and a "partial wet spell" could be used following the same pattern, such as 29 days with a mean daily rainfall of 0·30 in. or more.

This would give six categories: absolute drought, partial drought, dry spell, rain spell, partial wet spell, and wet spell. However these six are still inadequate, since the severity of the wet-spell criteria is such that many stations are excluded from ever attaining it, whilst the suggested "partial wet spell" also will not be easily achieved. On the other hand the difficulty of attaining either an absolute or a partial drought at wet stations calls for another dry-weather category. Two more varieties would greatly assist observers to analyse their records on standard lines. A period of 29 days with a mean daily rainfall of 0·04 in. or less might be adopted and called a "partial dry spell" and also one of 29 days with a daily mean of 0·20 in. or more which could be called a "partial rain spell".

This gives the completed list of categories as follows:—

Dry periods

*Absolute drought—at least 15 consecutive days each with less than 0·01 in. per day
*Partial drought—at least 29 consecutive days with a daily mean of 0·01 in. or less
Partial dry spell—at least 29 consecutive days with a daily mean of 0·04 in. or less
*Dry spell—at least 15 consecutive days each with less than 0·04 in. per day.

Wet periods

*Rain spell—at least 15 consecutive days with 0·01 in. or more per day
Partial rain spell—at least 29 consecutive days with a daily mean of 0·20 in. or more
Partial wet spell—at least 29 consecutive days with a daily mean of 0·30 in. or more
*Wet spell—at least 15 consecutive days each with 0·04 in. or more per day.

*Already adopted.

Such a classification, whilst slightly more complex than that in use, does find room for those annoying days of slight rain which cause dry periods to be registered as normal, or for the single day of "trace" which leaves events like the rains of November and December 1951 with no special significance in the examination of climatic history.

W. E. RICHARDSON

The Grove, Alston, Cumberland, October 23, 1954

NOTES AND NEWS

Hail from clear sky

Flying Officer R. H. Fortescue of Royal Air Force Station, North Weald, noticed the following phenomenon whilst flying at 0935 G.M.T. on Sunday September 5, 1954, about 22 miles from North Weald on a true bearing of 50°.

The aircraft was flying above 3 oktas cumulus with tops at about 6,000 ft. and 5 oktas altocumulus, base 12,000 ft. and tops about 15,000 ft. The east coast could be seen before entering an 8 oktas layer of cirrus. The pilot did not see any cumulonimbus cloud. On climbing through thick, almost solid, cirrus base 21,000 ft. tops 31,000 ft. there was generally moderate and occasionally heavy turbulence. According to the pilot conditions similar to those found in flying through cumulus cloud were experienced. There was no cloud above the cirrus.

At 32,000 ft., in clear air and sunshine, average-sized hailstones were encountered; these were quite easily visible and very numerous. The noise of the impact of the hailstones could clearly be heard. It was also very turbulent. The pilot described the conditions as being very like those found when flying through a normal (low-level) hailstorm associated with cumulonimbus. The aircraft continued on track, still climbing, and the hail ceased on reaching 34,000 ft. about 15 miles further on. The pilot believes that he left the edge of the hailstone belt rather than climbed above it. On account of the nature of the exercise on which the aircraft was engaged it was impossible to ascertain the extent of the hailstone belt.

No condensation trails were formed by the aircraft and no icing or hailstones were observed in the cirrus cloud.

The indicated speed of the aircraft was 240 kt.; the aircraft was not fitted with a thermometer so no temperatures are available. There was no structural damage to the aircraft although it is possible that some of the paint was removed by the hailstones.

On the 0900 G.M.T. chart there was a shallow depression over north-east France and a shallow anticyclone covering East Anglia. Both were almost stationary. At levels above 500 mb. there was a shallow trough of axis orientated from north-north-east to south-south-west which was over central England at 0300 and moved eastwards to the North Sea during the day.

Slight rain was reported by stations on the east coast from Dungeness to Yarmouth. The only station in south-east England reporting cumulonimbus cloud at 0900 was Yarmouth and then only 2 oktas at 1,200 ft. Most stations were reporting approximately 7 oktas altocumulus and altostratus at about 10,000 ft.

The 0200 G.M.T. radio-sonde ascent from Crawley confirms the existence of cumulus tops at about 6,000 ft. and a layer of altocumulus between 600 and 500 mb. The ascent above 400 mb. appears to be potentially unstable and rather moist.

P. R. CRISPIN

[F. Rossman* describes a fall of large hailstones on May 27, 1931, at Feldberg Observatory, Black Forest, with a large cumulonimbus nearby but with partially blue sky overhead. H. Wichmann† explains the phenomenon as hail shot out of an inclined updraft in a cumulonimbus cloud.—Ed., M.M.]

REVIEWS

Indian Ocean oceanographic and meteorological data, 2nd edn, 12¼ in. × 8¾ in., pp. 31 + 24 charts, 31¾ in. × 27½ in. Koninklijk Nederlands Meteorologisch Instituut, De Bilt, 1952. Price: Text *fl.* 1.50, each chart *fl.* 2.50.

There are two schools of thought on the best way to publish charts of marine meteorological data. The charts are used mainly on the one hand by meteorologists and other scientists and on the other by mariners. Whereas the former users generally prefer to have their data on many separate charts for each month bound together in the form of an atlas, many mariners prefer to have all the data for one month on a single sheet. The ideal way of meeting these two requirements is to publish both, but this involves considerable extra expense and the Dutch Meteorological Institute have chosen a compromise. They have published their meteorological and surface ocean current data for the Indian Ocean on two separate sheets A and B for each month, together with a text in booklet form.

There are many representations of data on each of the main charts, but the use of several different colours has helped in their clarity. The omission of certain information has been necessary and none is given on swell, lightning or difference between air and sea temperatures.

The text explains how the statistics shown on the charts have been derived and also contains a detailed account of the occurrence of tropical cyclones in the Indian Ocean.

On sheet A for each month the following information is given on a main chart:—

(*a*) Surface ocean current roses for specified areas shown on the chart

(*b*) Direction and velocity of the mean vector currents for two-degree squares, together with the constancy of the current

(*c*) Isotherms of mean air temperature

(*d*) Isotherms of mean sea temperature.

On one smaller side chart on sheet A are shown the surface current circulation, based on the computed predominant currents, and the standard deviation of sea-surface-temperature observations, while on another are shown the mean

* ROSSMANN, F.; Ein bemerkenswerter Hagelfall: Sehr grosse, vereinzelt fallende Hagelsteine. *Met. Z., Braunschweig*, 57, 1940, p. 43.

† WICHMANN, H.; Über das Vorkommen und Verhalten des Hagels in Gewitterwolken. *Ann. Met., Hamburg*, 4 Jahrg., 1951, p. 218.

cloud amount, the percentage of fog duration, the percentage duration of precipitation and the standard deviation of air-temperature observations.

On chart B the following information is given:—

(*a*) Wind roses for five-degree squares

(*b*) Direction and velocity of the mean vector winds for two-degree squares together with the constancy of the wind

(*c*) Mean isobars

(*d*) Percentage frequency of gales (Beaufort force 8 or more)

(*e*) Number of tropical cyclones observed in each five-degree square.

On the side charts of sheet B are shown the tracks of tropical cyclones and the years in which they were observed.

The printing of these charts is really excellent, and the Dutch, while they have been limited in the amount of information that could be shown on the two sheets, have succeeded in including the most important data. The charts will be a most useful reference work on the meteorology and ocean currents of the Indian Ocean.

P. R. BROWN

An introduction to climate, 3rd edn. By G. T. Trewartha. McGraw-Hill Series in Geography, 10 in. × $7\frac{1}{2}$ in., pp. vii + 402, *Illus.*, McGraw-Hill, London. 1954. Price $7.00 or 50*s*.

This third edition of a book which is meant chiefly for geographers has been extensively revised to give more of a dynamical approach to the subject of climatology. The book is in two parts.

In Part I the author gives a very brief introduction, listing the climatic controls: (*a*) sun or latitude, (*b*) land and water, (*c*) semipermanent low-pressure and high-pressure cells, (*d*) wind and air masses, (*e*) altitude, (*f*) mountain barriers, (*g*) ocean currents, (*h*) storms; which, acting upon the climatic elements temperature, precipitation and humidity, air pressure and winds, produce types and varieties of weather and climate. Then follow chapters on each of the elements, air temperature, pressure and winds, moisture and precipitation, air masses and fronts, atmospheric disturbances and associated weather types, in that order. But each section, although admirable for the completeness of the description of the element, fails to emphasize the essential unity of all the chapters. What is needed is an expansion of the brief introduction into a chapter which shows the production of weather on a seasonal basis; the interrelation of temperature over land and sea with air-mass source regions and frontal zones; pressure and wind and transport of and modification of air masses, with a general account of consequent changes in associated weather. This chapter would necessarily be rather generalized, and some repetition would occur later, but it would give a most helpful background for the understanding of the following chapters. The reader would not then have to digest (in Chapter 2) a discussion on the jet stream and upper air waves before reading something about air masses and fronts.

Chapter 1 gives an account of solar energy and the heating and cooling of the earth's surface and atmosphere, and the temporal and geographical distribution of temperature, with sections on the mean duration of certain temperatures. I would have liked to have seen some discussion of within-month variations of temperature, with perhaps world maps for January and July of the average highest and lowest temperatures recorded in those months.

Chapter 2 describes the distribution of pressure and wind at the surface and 700 mb.; modifications of the surface winds and climate produced by terrestrial and oceanic influences; and in a section on the general circulation the author describes the westerly jet stream and its relation to weather cycles. The mean westerly jet stream of the northern-hemisphere winter is rather stronger over Japan (150–160 kt.) and north-east Africa and Arabia (100–120 kt.) than shown by the author; and although his notion of a westerly jet stream completely girdling the earth is probably true for the southern hemisphere (with winter speeds of 80–120 kt.) this is not true of the winter northern hemisphere jet stream, which shows very marked variations in speed and direction over the eastern Atlantic and eastern Pacific, with resultant vector means of only about 50 kt.

Mention should have been made of the strong easterly jet stream of the northern-hemisphere summer, associated with the furthest northerly progress of the intertropical front over the Asian and African continents. The mean jet-stream speed is 70–80 kt. at 100 mb. Over the Atlantic and Pacific Oceans the intertropical front is weak and there is no mean easterly jet stream. In fact over the Hawaiian Islands there is at 200 mb. a mean westerly wind of 30 kt., and at times westerly winds of over 100 kt. are recorded.

Chapter 3 gives an account of humidity and fog, formation of clouds, and the origin and forms of precipitation. Chapter 4 describes the origin and classification of air masses and fronts over the world, with further illustrative detail about air masses over North America, Asia, Europe and South America (but none for Africa or Australia).

Chapter 5, on atmospheric disturbances describes the middle-latitude cyclones and anticyclones, with illustrative detail chiefly for the North American continent; and gives an account of tropical cyclones and easterly waves. This chapter also has a long section on thunderstorms.

Part II begins by discussing various well known world classifications of climate. The author uses a modified form of the Köppen system, and gives a very clear description of his climatic groups, together with an excellent world map in colour (although it is a pity that the upland Aw subtype is not given in the legend).

The chapters that follow deal in turn with five great groups of climate: tropical rainy, dry, humid mesothermal, humid microthermal, and polar, together with their various subdivisions. Highland climates are also described.

The treatment is very systematic. For each group, a brief description of the type, location and boundaries and precipitation régime is followed by an account, for each subdivision, of the climatic elements and associated vegetation and zonal soils. Attention is paid first to properties which are common to the whole subdivision, and then variations in particular regions are mentioned.

This is a good scheme, but I feel that the upland Aw (tropical wet and dry) subtype has received inadequate attention. For the areas of Africa and South America concerned the reader is referred to the account of the Aw subdivision and the section on highland climates. In view of the size of the African area the author might have given illustrative local detail for this region.

Throughout the book there is an abundance of most useful diagrams, many of them large world maps. Data of average monthly temperature and rainfall for 167 stations are given in an appendix.

The book is an excellent work of introduction to climate, and with its emphasis on the world pattern of distribution of climate it offers to the student a very sound background for further climatological study and research.

A. F. JENKINSON

OBITUARY

Major-General the Right Hon. Sir Frederick Sykes, P.C., G.C.S.I., G.C.I.E., G.B.E., K.C.B., C.M.G.—We regret to report the death on September 30, 1954, of Sir Frederick Sykes, who was Controller-General of Civil Aviation in the Air Ministry from 1919 to 1922 and, as such, the member of the Air Council responsible for the Meteorological Office, during and for some years after, the transfer of the Office to the Air Ministry in October 1919.

He was appointed President of the Meteorological Committee, Sir Napier Shaw remaining Chairman, in October 1919. On the retirement of Sir Napier Shaw a year later, the post of President of the Committee was abolished and Sir Frederick became Chairman. He remained Chairman until he ceased to be Controller-General of Civil Aviation on the re-organization of the Department of Civil Aviation in 1922.

Sir Frederick was one of the first 100 men to obtain the Aero Club's pilot's certificate and he had a very distinguished career in the Royal Flying Corps before becoming Controller-General of Civil Aviation.

Sir George Simpson writes:—

The transfer of the status of the Meteorological Office in 1919 from that of a practically independent body under the control of a committee composed largely of scientists to a Government Department under a Ministry, and that a military Ministry, gave rise to very serious doubts, not only of the staff of the Office, but of scientists in general, especially those who took an active interest in the work of the Office. That the transfer was carried through with good feelings on the parts of both the Ministry and the Office was largely due to Sir Frederick Sykes.

Instead of finding itself ruled by uninterested soldiers and controlled by civil servants with their legendary red tape, as forecast by the critics, the Office found itself under the control of a distinguished soldier indeed, but one whose experience in the Royal Flying Corps and responsibility for the young and rapidly developing Department of Civil Aviation taught him the value of an efficient meteorological service.

Sir Frederick Sykes was deeply interested in the work of the Office; he took the Chair at all the meetings of the Meteorological Committee and was always ready to put the view of the Office before the Air Ministry and the Treasury. He started the Office on its new course and ensured those good relations between the staff of the Office and the civil servants which have been of inestimable value both to the Office and to the Ministry. As the new Director I was grateful for all the help he gave to me, and we remained good friends to the end of his life.

AWARDS

The L. G. Groves Memorial Prize for Meteorology has been awarded this year to Mr. G. A. Corby, B.Sc., Principal Scientific Officer, Meteorological Office, whose work at Northolt Airport has been such as to inspire the utmost confidence, not only in his own staff but in all connected with aircraft operation and aerodrome management. The meteorological service provided by Northolt has been of a standard probably unexcelled anywhere, and has been an important factor in the safety and regularity of short and medium haul aircraft operations. He has also played a leading part in developing the meteorological aspects of the variable fuel method of operations. Mr. Corby has devoted much time to the study of air flow over mountains and has recently produced a critical summary of the state of our current knowledge on this problem.

The L. G. Groves Memorial Award for Meteorological Air Observers has been awarded to Sergeant J. A. McCubbin (3032716) for meritorious work while serving as a Meteorological Air Observer with No. 202 Squadron. He joined the Squadron in February 1952, and since then he has completed over 100 meteorological reconnaissance flights involving 900 flying hours. He quickly reached a high standard of efficiency, which he has consistently maintained by reason of his great enthusiasm for his work and keen devotion to duty. His attitude towards flying and meteorology has been most praiseworthy, his morale has been of the highest order, and he has at all times set an admirable example to his colleagues.

BOOKS RECEIVED

Weers verwachtingen op lange termijn. By W. van der Bijl. 8 in. × 5½ in., pp. 128, *Illus.*, Koninklijk Nederlands Meteorologisch Instituut, Staatsdrukkerij-en Uitgeverijbedrijf, 's-Gravenhage, 1954. Price: *fl.* 1.75.

Yearbook, B. Geomagnetism, 1950. Koninklijk Nederlands Meteorologisch Instituut. No. 102, 13½ in. × 9½ in., pp. iv + 28, Staatsdrukkerij-en Uitgeverijbedrijf, 's-Gravenhage, 1953. Price: *fl.* 3.00.

Yearbook, A. Meteorology, 1952. Koninklijk Nederlands Meteorologisch Instituut. No. 104, 13½ in. × 9½ in., pp. xiii + 94, Staatsdrukkerij-en Uitgeverijbedrijf, 's-Gravenhage, 1953. Price: *fl.* 7.50.

METEOROLOGICAL OFFICE NEWS

Academic success.—To the lists published in the October and November numbers should be added:

General Certificate of Education (Advanced Level).—Physics, R. H. Powell.

Sports activities.—*Swimming.*—The Air Ministry Swimming Gala was held at Marshall Street Baths on September 15. Miss C. W. Fleming, Scientific Assistant at Renfrew, retained the Civil Service Breaststroke Championship and the Air Ministry Ladies' Championship. Miss L. Carter, Scientific Assistant at Shoeburyness was second in the latter event. In the Air Ministry Ladies' Relay Championship, the Meteorological Office "A" team (Misses Fleming, Carter and Earl) were first, and the Meteorological Office "B" team (Misses Jack, Wayne and Bowen) were second.

At the station swimming gala held at Bahrein, Senior Aircraftman J. Armitage won five cups and was declared Victor Ludorum.

WEATHER OF OCTOBER 1954

Mean pressure was below normal over the region north of the latitude of the Azores to Greenland and north-eastward to Scandinavia. The lowest mean pressure was 996 mb. between Greenland and Iceland, where the deficit below normal was 8 or 9 mb. The mean pressure was above normal over west and central Europe reaching 1021 mb. (5 mb. above normal) over south-west France.

The mean temperature was generally 2–4°F. above normal over much of Europe. This was to be expected from the mean pressure gradient which corresponded to south-westerly winds over Europe.

In the British Isles the weather was mild generally, excessively wet in the west and north but drier than usual over much of south and east England, with less than the average sunshine in most places.

The month opened with the arrival of moist air from the Atlantic bringing fog to the English-Channel coasts and cloudy, close weather inland. In southern districts temperature reached 70°F. locally on each of the first three days. A temporary influx of colder air on the 3rd was marked by local thunderstorms and considerable rainfall in places. The return of a south-westerly air stream on the 4th and 5th was accompanied by heavy rain in some areas, particularly in Wales, for example 3·95 in. at Blaenau Festiniog, Merionethshire, 2·84 in. at Corris, Montgomeryshire and 2·80 in. at Maesteg, Glamorganshire on the 4th. An anticyclone moved in from the Atlantic on the 6th and gave 7–9 hr. sunshine in most districts with frost here and there in the early hours of the following day. In some southern and western districts, even as far north as Prestwick, Ayrshire, night temperature fell below 50°F. for the first time this month. On the 8th a belt of rain and drizzle was followed by the development of fog which became widespread in the Midlands and north of England on the morning of the 9th. By the 9th a low-pressure area, reinforced by a tropical cyclone from 2,000 miles further south, had moved north-east from south Greenland and this maintained fresh or strong west-south-westerly winds and changeable weather over the British Isles for several days; there was some sunshine and occasional rain or showers in all parts on most days and hail was recorded in north Scotland on the 10th. During the 13th cold air penetrated southward to northern England and small depressions moving along its boundary gave unsettled, rainy weather for nearly a week. Rainfall was heavy and prolonged in south Scotland, north Wales and north England, causing floods in these districts. Among the heavier daily falls were 4·00 in. at Blaenau Festiniog and 3·28 in. at Corris on the 14th, 3·28 in. at Borrowdale, Cumberland on the 15th, 2·44 in. at Blaenau Festiniog on the 16th, 2·93 in. at Borrowdale, 2·78 in. at Omagh, County Tyrone, 2·47 in. at Glenkiln, Kirkcudbrightshire and 2·41 in. at Cape Wrath, Sutherland on the 17th and 3·25 in. at Glenshiel, Inverness-shire and 2·98 in. at Patterdale, Westmorland on the 18th. On the other hand rainfall in south-east and east England during this period was mainly slight. Weather was generally cloudy, though warm; Holyhead had no sunshine for the week 12th–18th. Temperature reached 70°F. in East Anglia on the 17th and was nearly as high on the following day. From the 19th weather became somewhat brighter and cooler, but with substantial rainfall (particularly in Wales and northern England) on the 22nd and 23rd, 3·84 in. at Blaenau Festiniog, 3·00 in. at Wet Sleddale, Westmorland and at Bethesda, Caernarvonshire, and 2·48 in. at Slaidburn, West Riding of Yorkshire, on the 23rd. On the 23rd floods caused a landslide on the Holyhead road in the Nant Ffrancon pass. In the early morning of the 24th 1·34 in. was registered in about 90 min. at Hastings. Cool northerly winds spread over the country on the 24th and 25th and in spite of 7–10 hr. sunshine on the 25th the temperature did not exceed 50°F. in most places and the arrival of an anticyclone from the Atlantic was accompanied by the most widespread frost of the autumn on the morning of the 26th, with a grass minimum of 17°F. at such widely separated places as Shoeburyness, Castle Archdale and Eskdalemuir. On the 26th, however, rain and strong south-easterly winds spread in from the Atlantic over the whole country followed by bright weather until the 30th, though with showers that were heavy in the north and west. More flooding occurred in south Scotland and the Lake District; on the 27th 2·30 in. rain was registered at Onich, Inverness-shire, and on the 28th 3·19 in. at Haweswater and 2·21 in. at Ettrich, Selkirkshire. During this period it was generally mild and, on the 27th, London had its warmest late October day for five years. A trough of low pressure moving east across England and Wales gave mainly cloudy weather with rain or showers in that area on the 31st.

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 ...	73	23	+3·2	122	+3	84
Scotland	68	23	+1·0	190	+5	89
Northern Ireland ...	65	25	+1·9	191	+5	62

RAINFALL OF OCTOBER 1954

Great Britain and Northern Ireland

County	Station	In.	Per cent. of Av.	County	Station	In.
London	Camden Square ...	2·19	83	*Glam.*	Cardiff, Penylan ...	6·52
Kent	Dover	1·58	41	*Pemb.*	Tenby	6·83
,,	Edenbridge, Falconhurst	2·47	69	*Radnor*	Tyrmynydd	8·84
Sussex	Compton, Compton Ho.	3·62	79	*Mont.*	Lake Vyrnwy	12·91
,,	Worthing, Beach Ho. Pk.	1·73	48	*Mer.*	Blaenau Festiniog ...	31·09
Hants.	Ventnor Park	3·50	87	,,	Aberdovey	9·80
,,	Southampton (East Pk.)	3·20	81	*Carn.*	Llandudno	5·29
,,	South Farnborough ...	2·12	66	*Angl.*	Llanerchymedd ...	7·76
Herts.	Royston, Therfield Rec.	2·14	79	*I. Man*	Douglas, Borough Cem.	8·97
Bucks.	Slough, Upton	2·52	90	*Wigtown*	Newton Stewart ...	8·49
Oxford	Oxford, Radcliffe ...	2·15	74	*Dumf.*	Dumfries, Crichton R.I.	8·15
N'hants.	Wellingboro' Swanspool	2·05	81	,,	Eskdalemuir Obsy. ...	12·48
Essex	Shoeburyness	1·35	57	*Roxb.*	Crailing...	4·65
,,	Dovercourt	1·46	61	*Peebles*	Stobo Castle	7·00
Suffolk	Lowestoft Sec. School ...	1·59	57	*Berwick*	Marchmont House ...	5·24
,,	Bury St. Ed., Westley H.	1·91	70	*E. Loth.*	North Berwick	5·67
Norfolk	Sandringham Ho. Gdns.	3·22	106	*Midl'n.*	Edinburgh, Blackf'd. H.	6·17
Wilts.	Aldbourne	2·77	82	*Lanark*	Hamilton W. W., T'nhill	8·67
Dorset	Creech Grange... ...	4·03	79	*Ayr*	Colmonell, Knockdolian	7·59
,,	Beaminster, East St. ...	3·74	84	,,	Glen Afton, Ayr San. ...	10·05
Devon	Teignmouth, Den Gdns.	2·44	63	*Renfrew*	Greenock, Prospect Hill	10·75
,,	Ilfracombe	6·45	141	*Bute*	Rothesay, Ardencraig ...	8·98
,,	Princetown	10·15	121	*Argyll*	Morven, Drimnin ...	9·83
Cornwall	Bude, School House ...	3·90	96	,,	Poltalloch	11·01
,,	Penzance	3·28	70	,,	Inveraray Castle ...	15·51
,,	St. Austell	4·09	78	,,	Islay, Eallabus	7·60
,,	Scilly, Tresco Abbey ...	2·57	67	,,	Tiree	5·50
Somerset	Taunton	1·75	54	*Kinross*	Loch Leven Sluice ...	8·23
Glos.	Cirencester	3·80	115	*Fife*	Leuchars Airfield ...	5·71
Salop	Church Stretton ...	3·86	105	*Perth*	Loch Dhu	13·75
,,	Shrewsbury, Monkmore	4·36	156	,,	Crieff, Strathearn Hyd.	7·20
Worcs.	Malvern, Free Library...	2·97	100	,,	Pitlochry, Fincastle ...	6·11
Warwick	Birmingham, Edgbaston	3·51	126	*Angus*	Montrose, Sunnyside ...	5·14
Leics.	Thornton Reservoir ...	3·65	130	*Aberd.*	Braemar	6·04
Lincs.	Boston, Skirbeck ...	2·51	92	,,	Dyce, Craibstone ...	5·14
,,	Skegness, Marine Gdns.	2·29	84	,,	New Deer School House	5·37
Notts.	Mansfield, Carr Bank ...	3·15	104	*Moray*	Gordon Castle	5·02
Derby	Buxton, Terrace Slopes	8·16	166	*Nairn*	Nairn, Achareidh ...	5·47
Ches.	Bidston Observatory ...	4·38	134	*Inverness*	Loch Ness, Garthbeg ...	7·25
,,	Manchester, Ringway...	5·50	177	,,	Glenquoich	17·46
Lancs.	Stonyhurst College ...	9·19	205	,,	Fort William, Teviot ...	14·62
,,	Squires Gate	7·60	215	,,	Skye, Broadford ...	13·97
Yorks.	Wakefield, Clarence Pk.	3·27	114	,,	Skye, Duntuilm ...	8·64
,,	Hull, Pearson Park ...	3·95	133	*R. & C.*	Tain, Mayfield... ...	6·29
,,	Felixkirk, Mt. St. John...	4·15	144	,,	Inverbroom, Glackour...	9·30
,,	York Museum	2·95	110	,,	Achnashellach	13·39
,,	Scarborough	3·78	121	*Suth.*	Lochinver, Bank Ho. ...	8·13
,,	Middlesbrough... ...	3·83	128	*Caith.*	Wick Airfield	5·67
,,	Baldersdale, Hury Res.	7·19	194	*Shetland*	Lerwick Observatory ...	5·17
Norl'd.	Newcastle, Leazes Pk....	4·40	142	*Ferm.*	Crom Castle	6·80
,,	Bellingham, High Green	7·32	187	*Armagh*	Armagh Observatory ...	5·24
,,	Lilburn Tower Gdns. ...	4·39	119	*Down*	Seaforde	7·01
Cumb.	Geltsdale	9·13	245	*Antrim*	Aldergrove Airfield ...	5·79
,,	Keswick, High Hill ...	13·58	243	,,	Ballymena, Harryville...	7·76
,,	Ravenglass, The Grove	7·53	174	*L'derry*	Garvagh, Moneydig ...	5·19
Mon.	A'gavenny, Plâs Derwen	4·56	99	,,	Londonderry, Creggan	5·30
Glam.	Ystalyfera, Wern House	15·14	220	*Tyrone*	Omagh, Edenfel ...	8·63

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