M.O. 559 AIR MINISTRY

METEOROLOGICAL OFFICE

THE METEOROLOGICAL MAGAZINE

VOL. 81, No. 965, NOVEMBER 1952

RELATION OF THE HEIGHT OF THE MAXIMUM WIND TO THE LEVEL OF THE TROPOPAUSE ON OCCASIONS OF STRONG WIND

By E. E. AUSTIN, M.A. and J. K. BANNON, B.A.

Introduction.—Professor G. M. B. Dobson, in a classical paper[1], examined the variation of wind with height and showed that over Europe the maximum wind speed usually occurs just below the level of the tropopause. The data for Dobson's analysis were observations of wind made by following the path of sounding balloons, and such observations were necessarily obtained on occasions of little cloud and light or moderate wind; the maximum wind exceeded 60 kt. on only nine occasions. A similar but less extensive analysis is described in the present note using the wind and temperature observations made at Larkhill and Lerwick but restricting occasions to those when the maximum wind was 70 kt. or more.

Statistics of level of maximum wind and tropopause.—During the period 1948–50 four upper air observations were normally made each day at Larkhill and Lerwick. From these observations those with a maximum wind speed $\geqslant$ 70 kt. were extracted. Frequency tables for each station were then prepared, for ranges of 10 mb., for

(*a*) pressure at the level of maximum wind
(*b*) pressure at the tropopause
(*c*) pressure at the level of maximum wind minus the pressure at the tropopause.

These frequencies are shown in the histograms in Fig. 1. The mean values of (*a*), (*b*) and (*c*) for the whole period and the standard deviations are given in the first part of Table I. Also in this table are the correlation coefficients between (*a*) and (*b*) for the two stations. In the latter part of Table I the same statistics are given for the six months May to October only.

Fig. 2 shows mean monthly values of tropopause pressure and pressure at the level of maximum wind for each month of the period 1948–50 for both Larkhill and Lerwick. The number of observations available in each month is also given.

Discussion.—The results presented in Table I and Figs. 1 and 2 do not agree with Dobson's findings for what he calls high and moderate winds, which showed that the level of maximum wind usually occurred just below the tropopause. This discrepancy is not surprising as in Dobson's data the great majority of maximum winds were less than 60 kt. Winds of 70 kt. or more

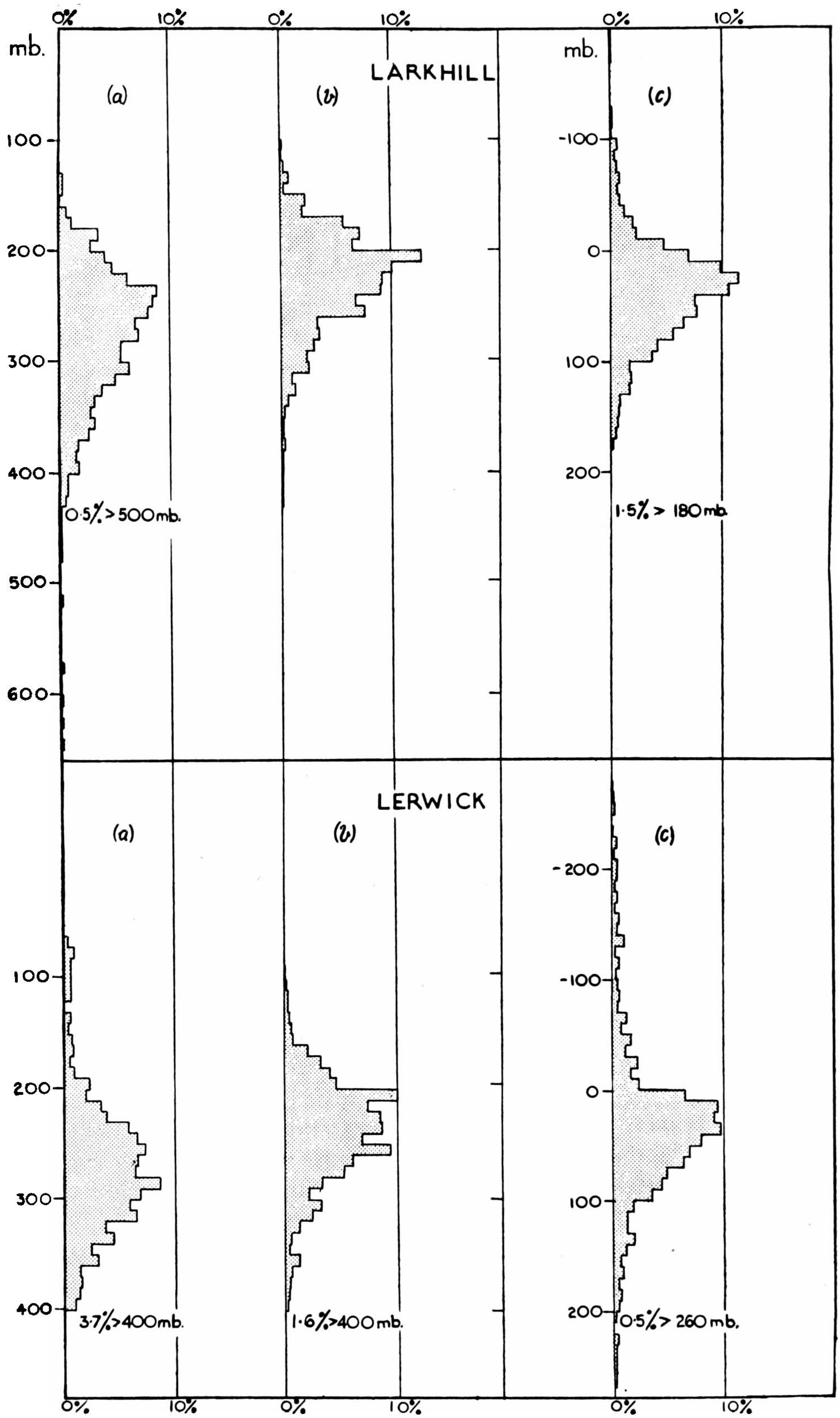


FIG. 1—FREQUENCIES OF (*a*) PRESSURE AT LEVEL OF MAXIMUM WIND, (*b*) TROPOPAUSE PRESSURE, AND (*c*) DIFFERENCE IN THESE PRESSURES
Maximum wind > 70 kt.

TABLE I—STATISTICS OF THE PRESSURE AT THE LEVEL OF MAXIMUM WIND AND AT THE TROPOPAUSE FOR OCCASIONS OF WIND ⩾ 70 KT.

Period: 1948–50

	All months				May–October only			
	Level of maximum wind (*a*)	Tropopause (*b*)	Difference (*c*)	Correlation between (*a*) and (*b*)	Level of maximum wind (*a*)	Tropopause (*b*)	Difference (*c*)	Correlation between (*a*) and (*b*)
	mb.	mb.	mb.		mb.	mb.	mb.	
LARKHILL								
Mean pressure	268	226	42	0·43	258	219	39	0·33
Standard deviation	58	45	56	—	52	39	54	—
LERWICK								
Mean pressure	278	244	34	0·18	281	239	42	0·28
Standard deviation	71	52	81	—	57	49	64	—

over Great Britain in the upper troposphere and lower stratosphere, however, are in most cases associated with a jet stream, and the tropopause surface in such circumstances has considerable slope and is often discontinuous (see, for example, Murray and Johnson[2]). A sounding through, or on the anti-cyclonic side of, the axis of a jet stream will find the level of maximum wind below the tropopause; a sounding on the cyclonic side of the jet stream close to the axis will also find the level of maximum wind below the tropopause, but if further from the axis and in the zone of discontinuous or sloping tropopause or through the true polar tropopause, then the tropopause may be at or below the level of maximum wind. Since the maximum wind falls off rapidly with horizontal distance on the low-pressure side of a jet stream, occasions of maximum winds ⩾ 70 kt. are more likely to be those near or on the anticyclonic side of a jet-stream axis. This, presumably, explains the mean pressure at the level of maximum wind being higher, in most cases, than the mean tropopause pressure, as seen in Fig. 2.

Further confirmation of these ideas is seen in the comparison of the monthly mean tropopause pressures for the occasions of strong winds (⩾70 kt.) with the means for all occasions; for the three years considered, the monthly mean tropopause pressure for strong winds was 12 mb. lower at Lerwick and 7 mb. lower at Larkhill, on the average, than the corresponding monthly mean tropopause pressure for all occasions. Of the 36 months considered there were only eight months for each station respectively, in which the mean tropopause pressure for all occasions was less than the corresponding mean pressure on occasions of strong wind. These figures support the hypothesis that the majority of soundings of strong wind, if associated with a jet stream, were through the higher, warm-air tropopause.

The differences between the statistics for Lerwick and Larkhill are interesting. At Lerwick, though the mean pressure at the level of maximum wind is greater than that of the tropopause, there is a much greater variation of the level of maximum wind than at Larkhill (see Table I and Fig. 1). This is very largely because the level of maximum wind at Lerwick in winter and early spring is often well into the stratosphere. These occasions are mainly associated with fresh arctic air just to the north of the British Isles, and though the tropopause at Lerwick is then below the average height and presumably a true arctic-type tropopause, yet the wind continues to increase above it, indicating a cold stratosphere over the Norwegian Sea. Riehl[3] has drawn attention to the very

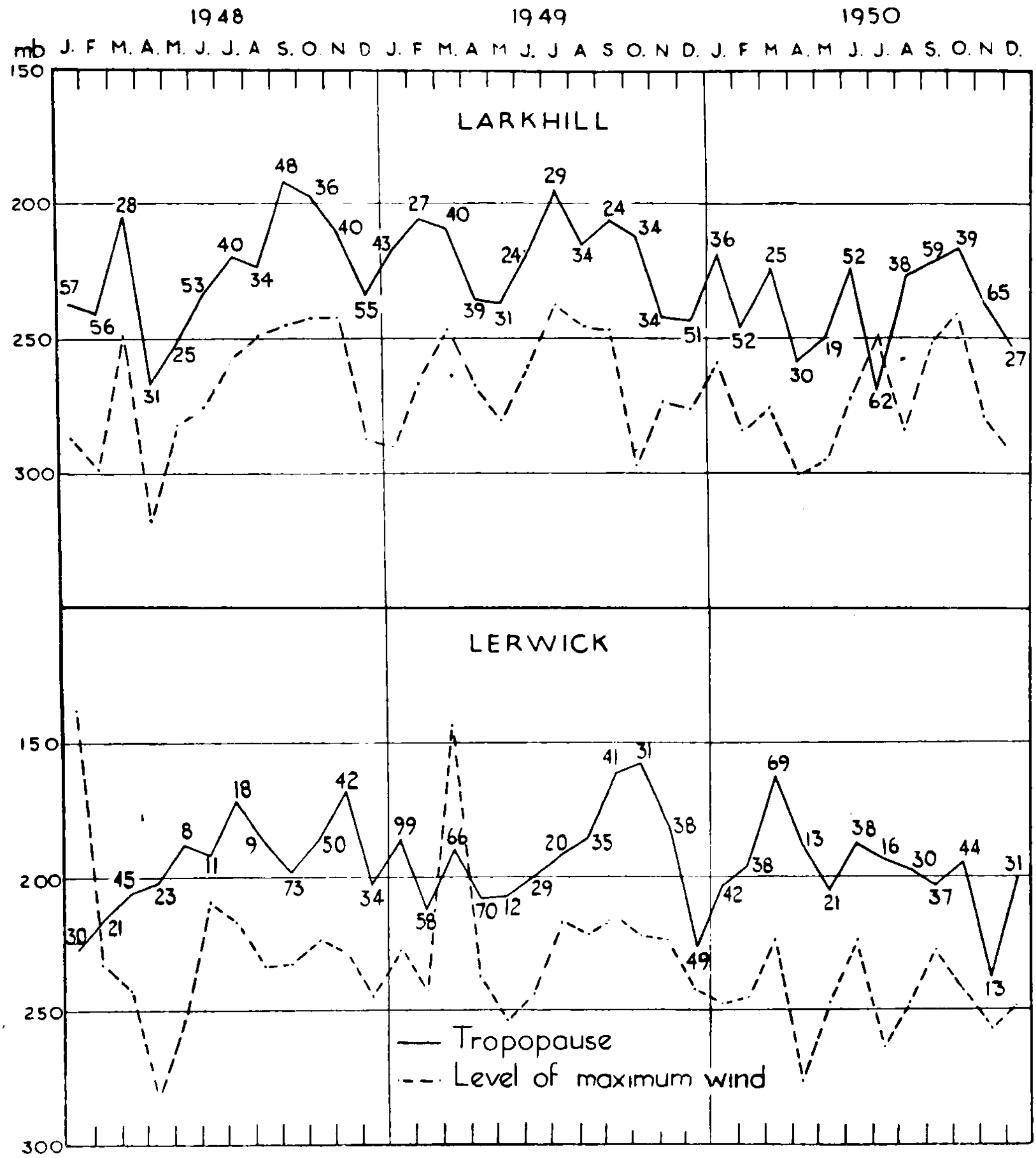


FIG. 2—COMPARISON OF PRESSURE AT TROPOPAUSE WITH LEVEL OF MAXIMUM WIND ON OCCASIONS WITH MAXIMUM WIND ⩾ 70 KT.

The figures give the numbers of observations for each month.

cold stratosphere which is sometimes found in winter over the semi-permanent depression at the 300-mb. level over and to the north of Canada, contrasting it with the more usual situation when the polar stratosphere is comparatively warm, the wind decreasing with height above the tropopause. These occasions of wind increasing with height in the stratosphere occur frequently at Lerwick in winter and early spring; it is seen from Fig. 2, for example, that in January 1948 and March 1949 the mean level of the maximum wind was well above the mean tropopause level. In summer, however, the relation between the level of maximum wind and the tropopause at Lerwick is more like that at Larkhill. The latter part of Table I, for the months May to October, demonstrates this.

Conclusions.—General conclusions to be drawn from the above analysis seem to be that with high winds, the maximum wind over the British Isles occurs most frequently at a pressure between 20 and 40 mb. higher than that of the tropopause. Though the monthly means usually vary in sympathy (Fig. 2) correlation between the levels of the tropopause and the height of maximum wind is small. In winter, at Lerwick, there are often occasions when the maximum wind occurs well above the tropopause, but such occasions are much less frequent at Larkhill.

REFERENCES

1. DOBSON, G. M. B.; Winds and temperature gradients in the stratosphere. *Quart. J. R. met. Soc., London*, **46**, 1920, p. 54.
2. MURRAY, R. and JOHNSON, D. H.; Structure of the upper westerlies; a study of the wind field in the eastern Atlantic and western Europe in September, 1950. *Quart. J. R. met. Soc., London*, **78**, 1952, p. 186
3. RIEHL, H.; Variations in the structure of high-level cyclones. *Bull. Amer. met. Soc., Lancaster Pa.*, **31**, 1950, p. 291.

INTERPRETATION OF RAINFALL VARIABILITY

By J. C. FOLEY, B.Sc.

It has long been recognized that in addition to information regarding the average rainfall of a region it is important to know something of its behaviour in regard to variation from "normal" from one year to another. Various indices of variability have been proposed to denote this characteristic, but many writers have felt that they have not succeeded in their purpose. It may be that it is rather much to expect a single-value factor to express a quantity so variable and complex in itself.

Apart from the value of deriving a simple measure of rainfall variability which will meet practical requirements it is of interest to be able to form a picture of what variability really signifies, and how, over a long period of years, the rainfall amounts at any particular place are distributed in relation to a modal or "normal" value. The purpose of this paper is to discuss variability of rainfall from this point of view.

Various methods of expressing variability or reliability of rainfall are summarized by Loewe[1]. These include:—

Rainfall range—difference between the highest and lowest annual amounts recorded in the series of years.

Relative rainfall range—measure of variation used by Gherzi, the ratio of the rainfall range to the average rainfall.

Hellmann's ratio of variation, or variability quotient—ratio of the amounts recorded in the wettest and driest years in the series.

Average variability—(*a*) absolute average variability, or the sum of deviations from the average divided by the number of years; (*b*) average relative variability, the absolute average variability divided by the average rainfall.

Relative variability—term applied by Conrad to the absolute average variability expressed as a percentage of the arithmetic mean.

Loewe discusses at length other expressions for variability, Maurer's variability indices. These forms of index are designed to meet objections to some of the simpler forms of ratio referred to above, and it is claimed that they are more satisfactory for comparing variabilities in regions of very different average rainfall. For example, the magnitude of an index which is derived by dividing the highest by the lowest recorded annual totals depends to some degree on the magnitude of the extremes of rainfall. Similarly if we take the difference between the highest and lowest totals and divide this difference by the average rainfall, the result is influenced by the magnitude of the average rainfall. The index will tend to be high in a case where the average rainfall is low and in an extreme case tends to be infinitely high. Thus the magnitude of average relative variability index $\sum|x - \bar{x}|/n\bar{x}$ will tend to become high in a low rainfall region since the smaller $\bar{x}$ becomes, the larger is the value of the expression. It is true that $\sum|x - \bar{x}|$ is also low in low rainfall regions but the ratio $\sum|x-\bar{x}|/\bar{x}$ is not as a rule constant. We may reduce the ratios $\sum|x - \bar{x}|/n\bar{x}$, for all stations compared, to a standard basis of 100 for $\bar{x}$, but still the objection is not altogether overcome. It is stated by Conrad[2] that statistics of 360 stations scattered over the earth yielded a correlation between V_r, the value of the expression for relative variability, and $\bar{x}$, the normal rainfall. This is not a linear correlation but a hyperbolic curve which for low values of $\bar{x}$ gives values of V_r rising sharply towards infinity (Fig. 1).

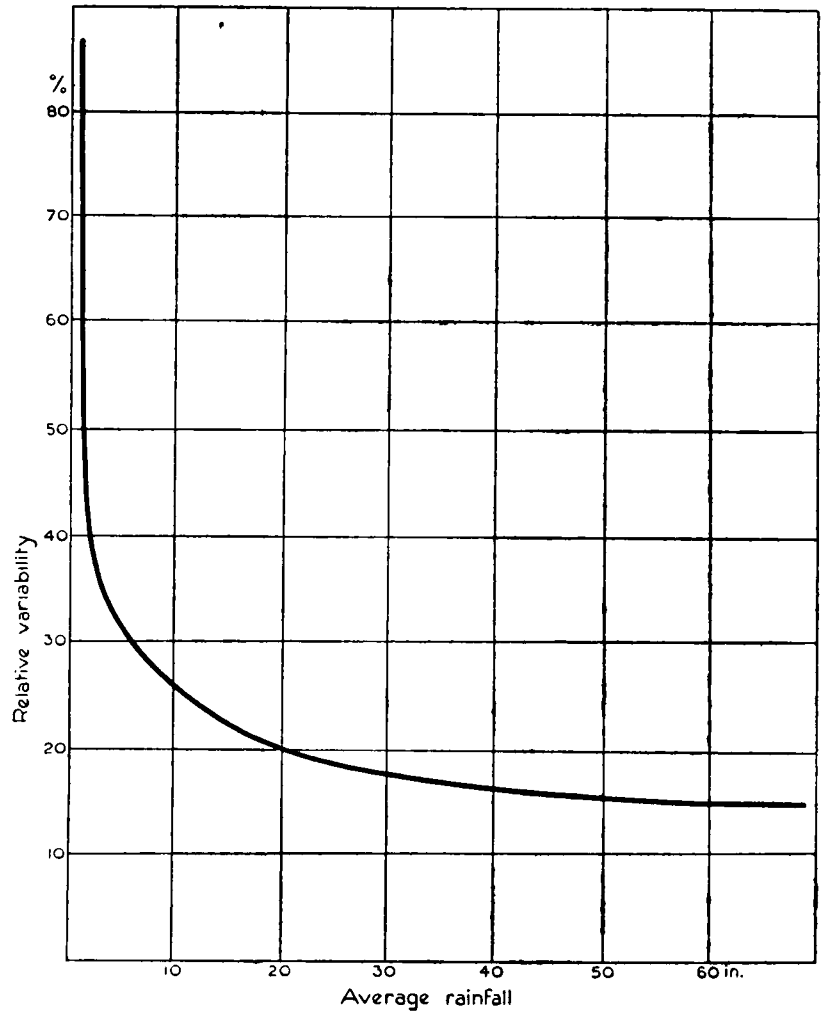


FIG. 1—COMPARISON OF RELATIVE VARIABILITY WITH AVERAGE RAINFALL (after Conrad[2])

Questions are thus raised as to how reliable are various expressions for variability, or rather, how serious is the error arising out of the mathematics of the derivation of an index. In particular, is the error of sufficient importance to warrant the employment of a highly complex and laborious process as an alternative?

There are one or two observations to be made regarding the basis of such expressions.

It must be remembered that all such expressions depend on the assumption that the relatively few samples analysed are representative of the very large number required to give an adequate basis for such an analysis. The number of samples at our disposal is small and by accepting these as the best available we admit the possibility of error.

A rainfall variability map has a limited application. Its significance is only apparent when read in conjunction with an average rainfall map. We should not seek for something more in it than what it purports to show. The criticism is sometimes made that a place in a semi-arid area may have the same variability index as a station in a wet region, but, whereas in the latter case the index would be of no particular significance in view of the abundance of rain, in the former case it may be of the highest significance. This criticism is valid if it is directed against the feature already referred to, namely the unsatisfactory nature of an index which reflects the mathematics of its derivation. It is reasonable to seek an index which is independent of such influences, but we should not infer that an index can express the magnitude of rainfall as well as its behaviour as regards deviation from an average.

This idea is carried further by some who claim that highly abnormal rainfall occurrences are of economic importance and should not be eliminated from the data used in the calculation of a variability index. Others argue that the index should indicate prevailing tendencies or the more normal experience. It is difficult to see how the importance of abnormal features can be disclosed by such an index. Such abnormalities may be disturbing factors which modify the index in such a manner that it no longer shows the normal characteristics of the place. The sections of this paper which follow are based on the assumption that the omission of extreme values is justified in order that the normal experience of a station may be more truly represented. A weakness of the relative variability index is that it includes unduly disturbing elements which it would be preferable to indicate in some other manner. For example, Burketown in Queensland has a much higher variability than surrounding stations according to some variability maps, but unless we examine the individual annual recordings of this station we cannot tell whether this feature is due to a peculiarity in the general experience of the locality or to the influence of a few abnormally high or low recordings. This is illustrated by a cumulative frequency graph in Fig. 2. If the abnormalities are systematically omitted we obtain an unequivocal expression for the normal experience. It will be noted that a moderately high percentage of high annual rainfalls at this station (contributed largely by tropical cyclones) accounts for the high variability index. There is a marked difference between this curve and that for Townsville (Fig. 2). Both stations have an index of approximately 500 according to Maurer's formula (Fig. 5). Burketown's experience might be described by regarding the upper 90 per cent. of the curve as representing the ordinary

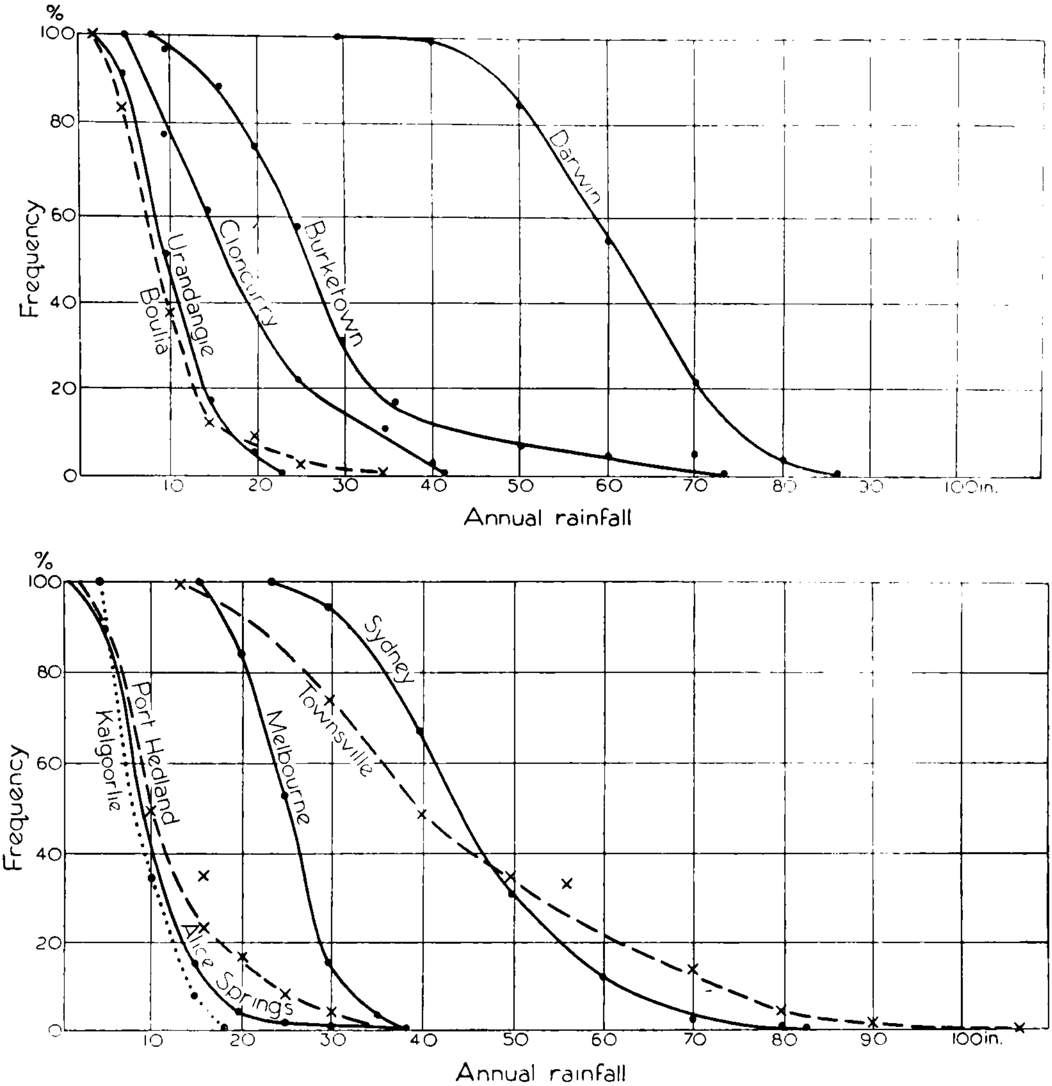


FIG. 2—CUMULATIVE FREQUENCY CURVE OF ANNUAL RAINFALL

In regions with summer rainfall the year is reckoned from July to June; elsewhere it is a calendar year

rainfall behaviour and the lower 10 per cent. as abnormal occurrences. No single index can be expected to reveal both features.

The relative variability index, apart from this fault if it may be conceded that it is a fault, seems reasonably accurate for practical purposes. The expression for relative variability is $100 \sum|x - \bar{x}|/n\bar{x}$.

According to Conrad, variabilities with an annual rainfall greater than 20–28 in., derived from this expression, can be compared with one another without serious error. An inspection of the graph on which this statement is based (Fig. 1) suggests that values of the index with an annual rainfall down to 10 in. may also be compared, with but a moderate degree of error. Values of variability in regions of low rainfall tend to be unduly high, but this is of little economic significance. In view of all the circumstances the employment of a laborious process of deriving an exact expression of variability, e.g. Maurer's indices, in preference to a simpler method for deriving an approximate value, does not seem to be justified.

An alternative expression for variability is the semi-interquartile range expressed as a percentage of the median. This method is said to give a convenient approximate measure of variation with the advantages that the quartiles and median are easily picked out.

It is said to be fairly "satisfactory when the frequency distribution is fairly symmetrical and uniform in its graduation from greatest to least; but if the distribution is conspicuously skew, or if there are erratic differences in frequency between successive values of the variable, it is better to choose a measure which gives the magnitude and position of each recorded observation its due weight in the deviation sum."[3]

Rainfall statistics usually give a skew distribution, but the amount of skewness is not large as a rule, and a smoothed distribution curve probably gives a closer approximation to the true rainfall experience than a summation of individual deviations from an arithmetic mean, or median, over the period for which records are available.

One of the most convenient forms of curve to work with is the cumulative frequency curve, sometimes called a graduation curve. The type of curve adopted for the purpose of this paper is one which expresses the percentage frequency of years in which the annual rainfall exceeds certain amounts (Fig. 2).

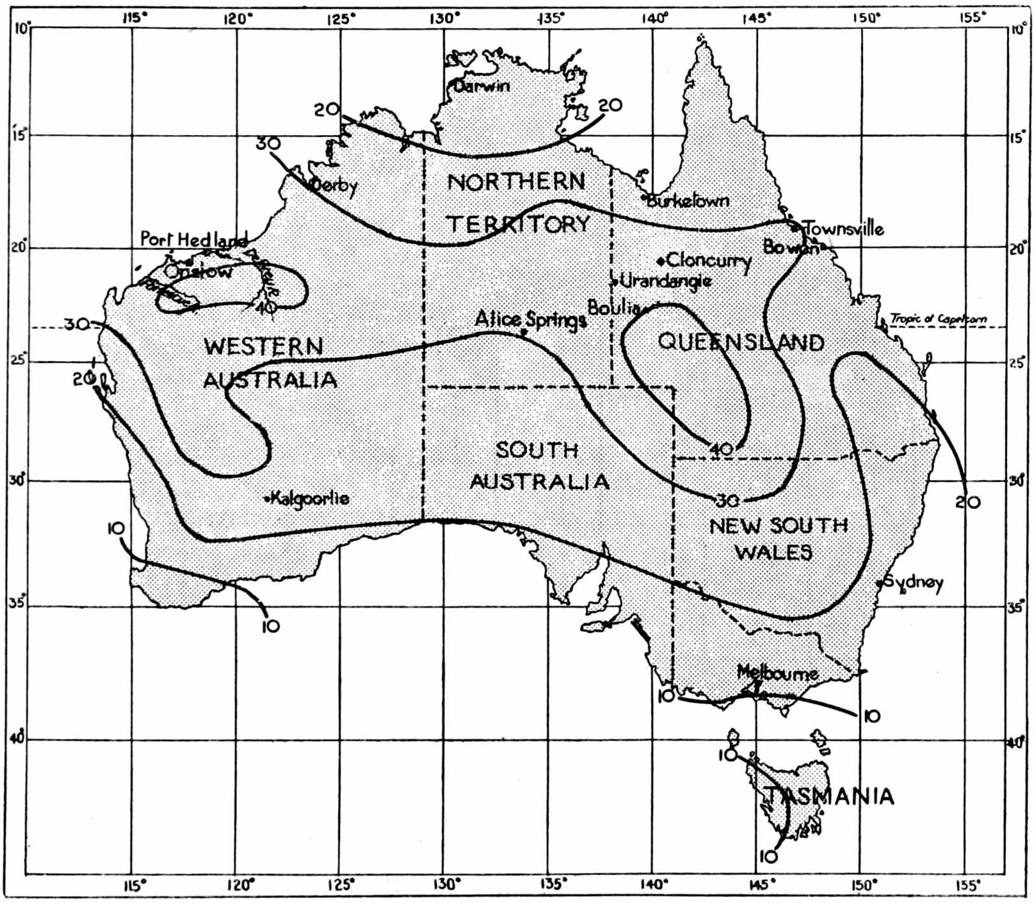


FIG 3.—RAINFALL VARIABILITY IN AUSTRALIA

$$\text{Variability} = \frac{\text{semi-interquartile range} \times 100}{\text{median}}$$

For example, the extreme lowest rainfall will be exceeded on 100 per cent. of occasions and the highest recorded rainfall on zero per cent. The median rainfall will be exceeded in 50 per cent. of the years, the lower quartile in 25 per cent. and so on. In the usual form of frequency curve the lower quartile would apply to low values which would be exceeded on 75 per cent. of the years. In this form of curve the magnitudes are inverted. From the steepest part of the curve we may read off the mode or the percentage of years in which the most frequently occurring amount is registered.

This curve serves to illustrate in a striking manner the meaning of variability. In a wet region the curve usually falls away gradually and extends over a wide range of rainfall values. In a dry region the curve will tend to fall steeply over a small range and to be confined to the field of small values. These features may appear surprising at first sight as it is commonly accepted that the

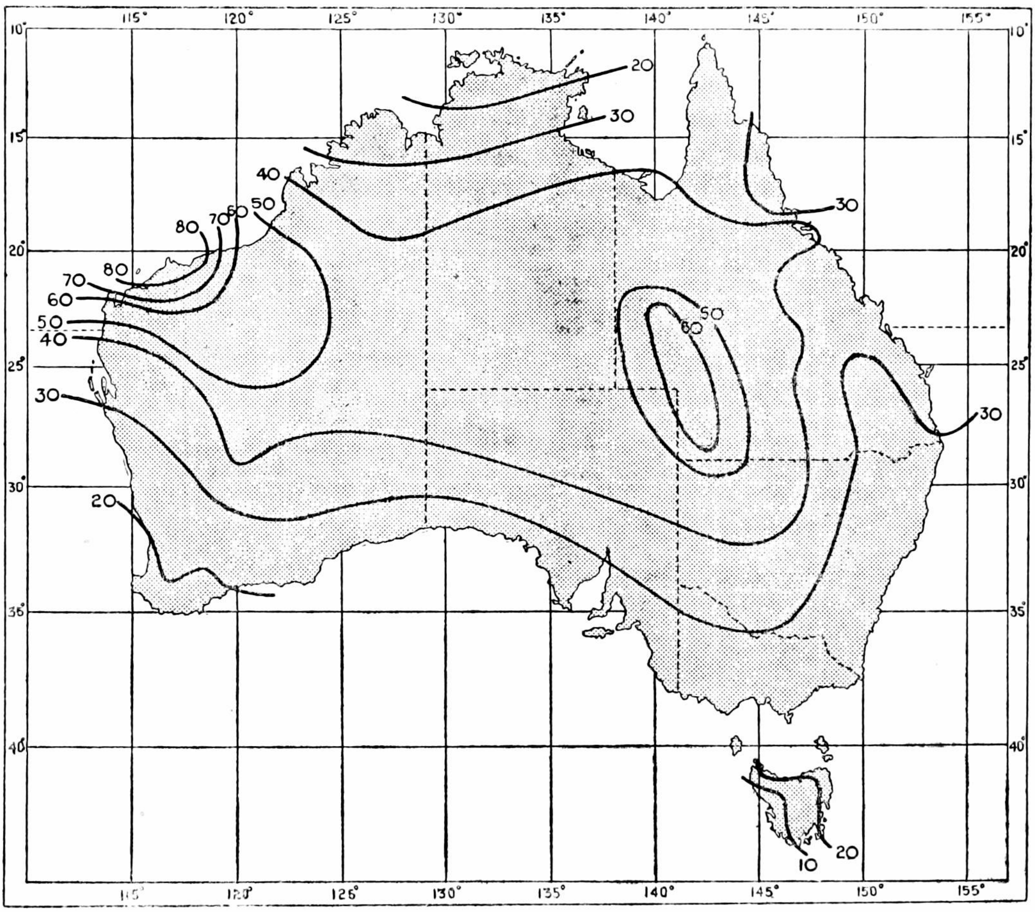


FIG. 4—RAINFALL VARIABILITY IN AUSTRALIA

$$\text{Variability} = \frac{95 \text{ per cent. range} \times 100}{4 \times \text{median}}.$$

lower the rainfall, the higher the variability. However, in the expression from which the variability is derived, the range, which varies approximately with the median, is divided by the median, i.e. the index is the ratio of large quantities in a wet region and of small quantities in a dry region. Such a curve clearly shows the quartile deviation or the deviations from any point chosen as a point of reference. The mean deviation from the average, or from the median, may also be looked upon as an integration of the deviations of all points on the curve from either the arithmetic mean or the median rainfall.

A variability map has been drawn based on the semi-interquartile range at 77 stations over Australia (Fig. 3). This shows the same general features as other well known maps based on the mean deviation from the arithmetic mean. Areas of maximum variability of over 40 per cent. occur over the Fortescue and De Grey regions of Western Australia and over south-western Queensland, while a variability of over 30 per cent. is found over inland areas between latitudes 20°S. and 25°S., touching the east coast at Townsville, the west coast between the tropic and Derby and projecting southward to 30°S. over Western Australia and north-western New South Wales. The lowest variabilities are found in western Tasmania, south Gippsland and on the south coast of Western Australia.

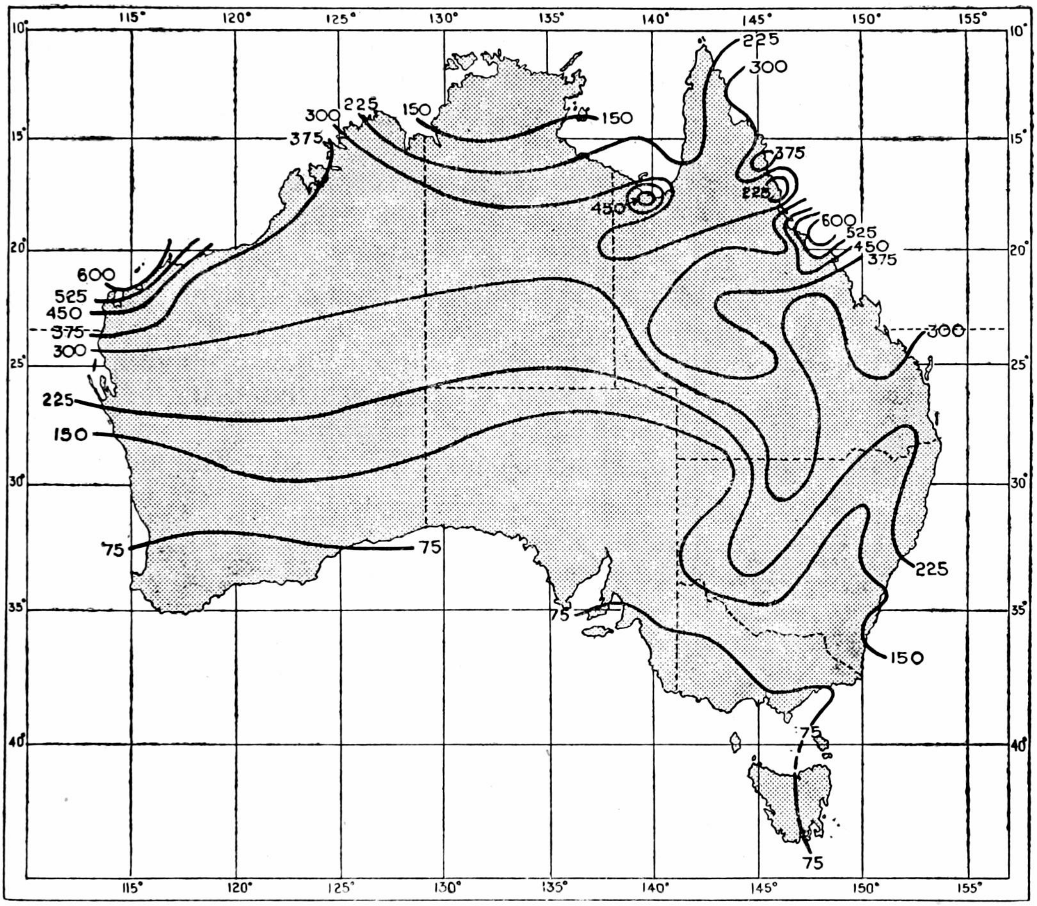


FIG. 5—MAURER'S AVERAGE VARIABILITY INDEX
(after Loewe[1])

An interesting map has been prepared by taking 95 per cent. of the frequencies instead of 50 per cent. as in the former case, and expressing one fourth of the range corresponding to these frequencies as a percentage of the median (Fig. 4).

The general distribution is similar to that of the previous map but with some important differences. The values of the index are generally higher than those of the map previously described. In the north-west of Western Australia they are twice as great and the area of maximum deviation has shifted to the coast between Onslow and Port Hedland. In the south-west of Queensland the variability is over 60 per cent. Areas of lowest variability are western Tasmania, the western and central districts of Victoria and the south-west of Western Australia. The Darwin region, however, compares with the south-west of Western Australia.

The 95 per cent. deviation probably gives a truer picture of the general rainfall experience and has an advantage over the relative variability map in that the disturbing effects of extreme values are largely eliminated. The smoothing of the curve tends to result in a truer frequency distribution.

A map by Loewe, based on Maurer's average variability index, is shown for comparison in Fig. 5. This map shows areas of maximum variability on the north-west coast of Western Australia and between Bowen and Townsville, Queensland. There is also a high local variability around Burketown, Queensland, which is eliminated in the first two maps described. A marked southward dip over south-western Queensland and western New South Wales is also shown, indicating a high variability over this area.

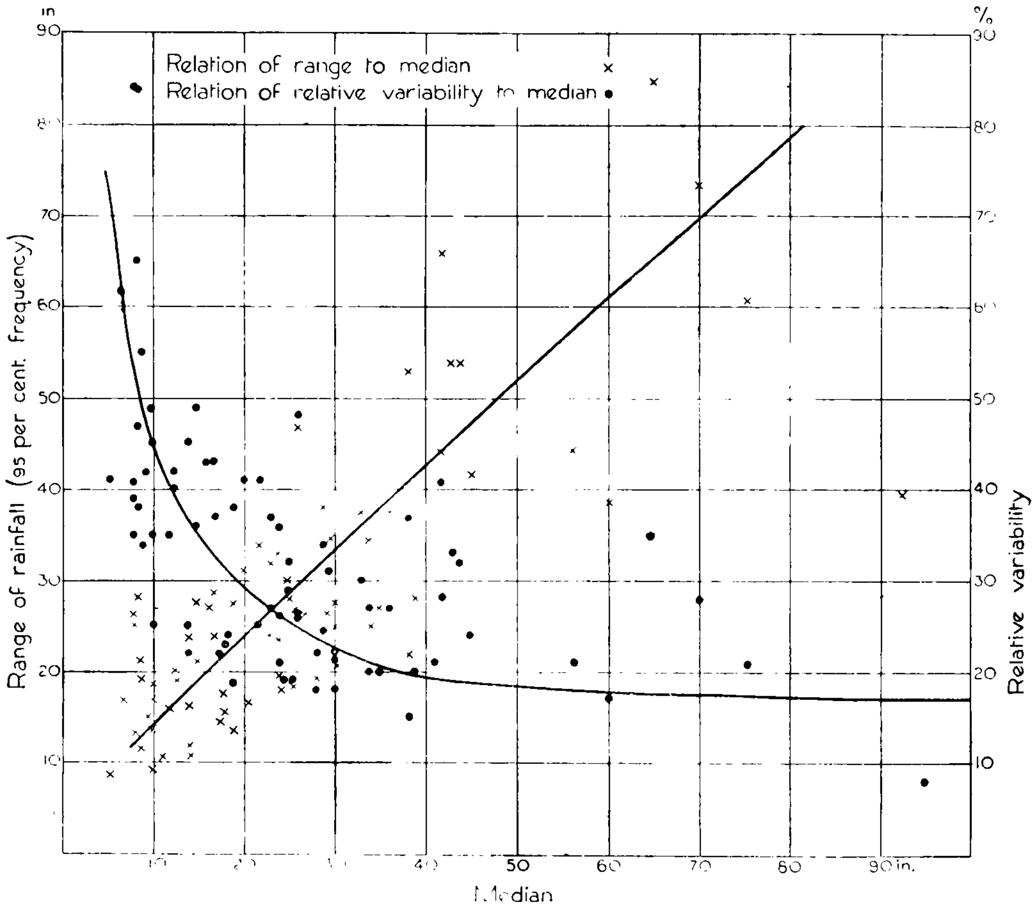


FIG. 6—RELATION OF RANGE OF RAINFALL (95 PER CENT. FREQUENCY) AND RELATIVE VARIABILITY TO MEDIAN RAINFALL

In order to obtain some indication of the change in value of the variability index with increase in the magnitude of the median, spot diagrams have been plotted of range against median for both the quartile deviations and the range of 95 per cent. of the frequencies. In the latter case, shown in Fig. 6, the ratios of range to median are close to unity, but for quartile deviations the ratio is approximately one to three. Some considerable scattering occurs in either case but this may be attributed to actual differences in the variability index. The variability index also is plotted against the median in Fig. 6; and, although there is a suggestion of a hyperbolic distribution, the very high values of the index occurring only with the rainfalls of under 10 in., even here the majority of values are about 40 per cent. or less. The diagram indicates that by taking 95 per cent. of the frequencies and using one fourth of the range to obtain a variability index a good comparison can be obtained between indices for wet and dry regions in Australia. The study has been limited to 77 stations. These stations are, however, fairly representative of various regions of the Commonwealth. Cumulative frequency graphs which have been drawn for all 77 stations indicate that there is a gradual change in the type of curve from one region to another.

REFERENCES

1. LOEWE, F.; Some considerations regarding the variability of annual rainfall in Australia. *Bull. Bur. Met. Aust., Melbourne*, No. 39, 1948.
2. CONRAD, V.; Methods in climatology. Cambridge Mass., 1944, p. 51.
3. JONES, D. C.; A first course in statistics. London, 2nd edn, 1924.

MEAN SEASONAL RESILIENCE OF THE ATMOSPHERE AROUND THE BRITISH ISLES 1948–50

By A. H. GORDON, M.S.

Shaw[1] states that the area on a tephigram between the environment curve and the lifting path curve of a parcel of air represents the surplus of energy developed by the operation of the environment upon unit mass of the working air over and above what is necessary merely to carry it upward through the environment. This information, derivable from the tephigram, shows the "liability" of the environment for the development of energy by the operation of unit mass of air.

When the "liability" of the atmosphere is negative we could re-define the "liability" as the "resilience", that is, the measure of the energy which would be available to restore the original position if a parcel of air were displaced upwards or downwards.

If adjacent vertical layers up to a common level are all lifted to that level then the total of all the areas enclosed by the two curves represents the total resilience of the atmospheric column considered. Values for various stations can be computed and a pattern drawn showing the geographical distribution of the potential energy of resilience. This technique can be applied synoptically to individual ascents, or climatologically to mean values for months, seasons or a period of years. The patterns produced may indicate regions where development is most likely to occur, either synoptically as suggested by Sumner[2] and Mook[3], or climatologically.

An example of the method is illustrated with mean seasonal values for the period 1948–50 inclusive for the ocean weather ship stations JIG* 53°50′N., 18°40′W. and ITEM* 60°00′N., 20°00′W. and the two British land stations Lerwick and Larkhill in order to compare land and ocean values and show their seasonal variation. The environment curves for the four stations have been constructed from mean seasonal values of temperature and humidity.

* Now known as stations JULIETT and INDIA.

It is considered that the use of mean values confined to seasons gives a sufficiently accurate approximation of the resilience of the atmosphere for comparing variations and producing patterns of the horizontal distribution. Each 100-mb. layer from 1000 to 700 mb. was lifted on the upper air diagram to 700 mb., and values of the resilience were obtained for each layer of 100-mb. thickness from the mean of the values for the upper and lower boundary levels of the layer. The areas were computed by planimeter and totalled for the 1000–700-mb. thickness.

Fig. 1 illustrates the seasonal variation of resilience of the 1,000–700-mb. layer at each of the four stations. The units are joules per gramme. In every case the air is stable and the values represent work that must be done on the atmospheric column to lift it to the 700-mb. level. Thus the atmosphere in the mean is stable and resilient at all stations for each season of the year. The curves for the two ocean stations are of similar form. Resilience is least in winter at ITEM and in winter and autumn at JIG and rises to a maximum in summer. Except in autumn ITEM is less resilient than JIG for the same season. L. D. Sawyer[4] has shown, on the basis of a 5-year period, that more depressions form and deepen over the Atlantic Ocean during the winter than during the summer half of the year. A higher liability would be in accordance with this greater frequency and intensity of cyclonic development.

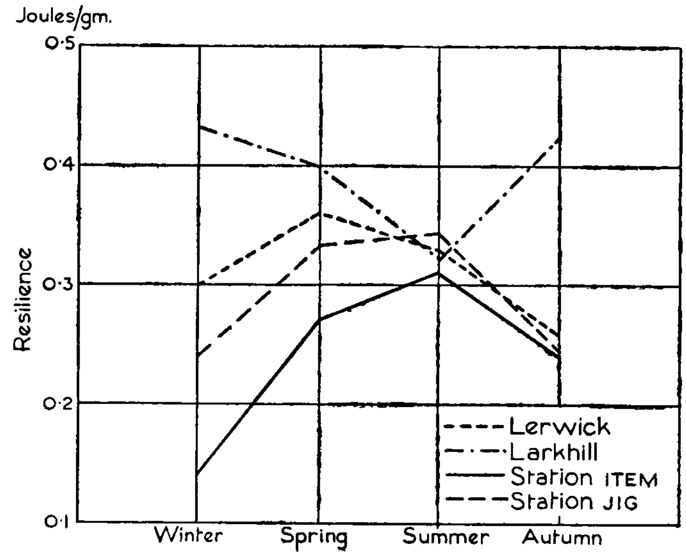


FIG. 1—SEASONAL MEAN VALUES OF RESILIENCE, 1948–50

The curve for Larkhill differs considerably. The resilience reaches a maximum in winter and a minimum in summer. This variation is the reverse of that which occurs over the ocean stations. The minimum value of resilience in summer at Larkhill is approximately the same as the maximum value at JIG in summer.

The curve for Lerwick follows the form of the curves for JIG and ITEM, although the maximum is reached in spring and the minimum in autumn. This might be expected since although Lerwick is on an island it may at times be temporarily influenced by land conditions, as, for example, local heating in summer.

The usefulness of this kind of representation lies in the comparison of the potential energy of the atmosphere from season to season and between land and oceanic climatic regions.

REFERENCES

1. SHAW, SIR N.; Manual of meteorology, Vol. III, Cambridge, 1930.
2. SUMNER, E. J.; Unusual deepening of a frontal depression over the British Isles. *Met. Mag., London*, **80**, 1951, p. 130.
3. MOOK, C. P.; Deepening of frontal depressions. *Met. Mag., London*, **80**, 1951, p. 335.
4. SAWYER, L. D.; Some regions of formation of depressions in the North Atlantic. *Prof. Notes met. Off., London*, **4**, No. 50, 1928.

METEOROLOGICAL RESEARCH COMMITTEE

The 21st meeting of the Physical Sub-Committee of the Meteorological Research Committee was held on June 11. A paper by Mr. E. Knighting[1] dealing with atmospheric turbulence as an aspect of random motion was considered. Two papers dealt with high-level cloud, one, by Mr. Durst[2], containing a report of an extensive sheet of high-level cloud in the tropics, and the other, by A. C. Best[3], presenting three reports of ice accretion in clear air or in cirrus cloud. The last two papers considered, one by Mr. Durst and Mr. Gordon[4] and one by Commander Darlington[5] presented data about the vertical gradient of humidity and temperature over the ocean.

ABSTRACTS

1. KNIGHTING, E.; Random motion and atmospheric turbulence. *Met. Res. Pap., London*, No. 728, S.C. III/130, 1952.

The turbulent motion of marked particles from a point source is compared to random walks of a cluster. As the cluster spreads, larger eddies take effect and the steps are made with increasing velocities. Mathematical discussion leads to the conclusion that turbulence is characterized by this "law of step size".

2. DURST, C. S.; High-level cloud in the tropics. *Met. Res. Pap., London*, No. 727, S.C. III/129, 1952.

In March 1952, in flight from Khartoum to Livingstone, continuous thin cirrus was observed between 10°40′N. and 16°S., at 45,000–50,000 ft. Photographs are given. Cloud is attributed to ice needles from condensation in rising and spreading air near the equator.

3. BEST, A. C.; Ice accretion in cirrus cloud. *Met. Res. Pap., London*, No. 730. S.C. III/131, 1952.

Earlier observations of temperature of spontaneous freezing of water droplets of different sizes are summarized, and suggest that at -50°C. liquid drops must be of diameter 1 μ or less. Three observations of icing in cirrus (one at -54°C.) indicating liquid drops are discussed.

4. DURST, C. S. and GORDON, A. H.; Some observations of vertical temperature and humidity gradients made from ocean weather ships. *Met. Res. Pap., London*, No. 714, S.C. III/125, 1952.

Psychrometer observations in May–September 1951 at JIG (52½°N., 20°W.) and ITEM (59°N., 19°W.), 0–50 ft. above sea surface are tabulated and vertical gradient of dew point compared with sea temperature, wind and weather.

5. DARLINGTON, C. R.; The variation of humidity with height over the ocean. *Met. Res. Pap., London*, No. 725, S.C. III/128, 1952.

During cruises in arctic and northern waters and in the south-west North Atlantic numerous observations of dry- and wet-bulb temperature were made at 0–30 ft. above sea. These are set out in detail with associated wind and weather. Mean profiles of temperature and vapour pressure are shown graphically. The theory of evaporation is set out and Montgomery's "evaporation coefficient" and rate of evaporation are calculated for unstable and stable, rough and smooth conditions, from vapour pressure at 0 and 20 ft. Results are erratic but in general agreement with theory.

ERRATA

July 1952, PAGE 198, line 25; *for* "Able and Baker . . . maturity." *read* "Able occurred off the Bahamas in the second half of May 1951 and Baker over the Atlantic south-east of Bermuda between August 2 and August 5, 1951."

August 1952, PAGE 244, line 42; *for* "June 18, 1952" *read* "January 18, 1952".

OFFICIAL PUBLICATIONS

The following publications have recently been issued:—

Annual Report of the Director of the Meteorological Office presented by the Meteorological Committee to the Secretary of State for Air for the year April 1, 1951 to March 31, 1952.

The Meteorological Office provides meteorological services for the Royal Air Force and Army, civil aviation, other government departments and public utility corporations, agriculture, the Merchant Navy, industrial concerns and the general public. The Report describes the organization by which these services are rendered. New meteorological offices have been opened to meet the needs of the expanding R.A.F., and in other respects also services have been improved or extended. Wherever possible, however, economies have been made, and in particular the programmes of radio-sonde ascents and of special meteorological flights by aircraft have been greatly reduced.

Interest in meteorological conditions at great heights has grown rapidly, largely because of the increasing amount of flying at heights above 40,000 ft. A new Branch of the Office was formed in May 1951 to deal with upper air climatology.

Among the many subjects of research mentioned in the Report are methods of forecasting weather for comparatively long periods, icing on aircraft, and the study of cloud structure by radar. Development work has continued on a number of instruments, particularly the radar theodolite and other radar methods of measuring upper winds.

The geophysical observatories at Kew, Lerwick and Eskdalemuir have maintained their series of observations and automatic records.

The responsibilities of the Office overseas have been slightly reduced by the handing over to local governments of all meteorological services in the West Indies and all services connected with civil aviation in Germany and Ceylon. Political disturbances in Egypt caused inconvenience, but did not interrupt the services provided for the armed forces in the Canal Zone.

Senior members of the staff have attended meetings of the World Meteorological Organization, the International Civil Aviation Organization and other international bodies.

Condensation trails from aircraft. 2nd edition.

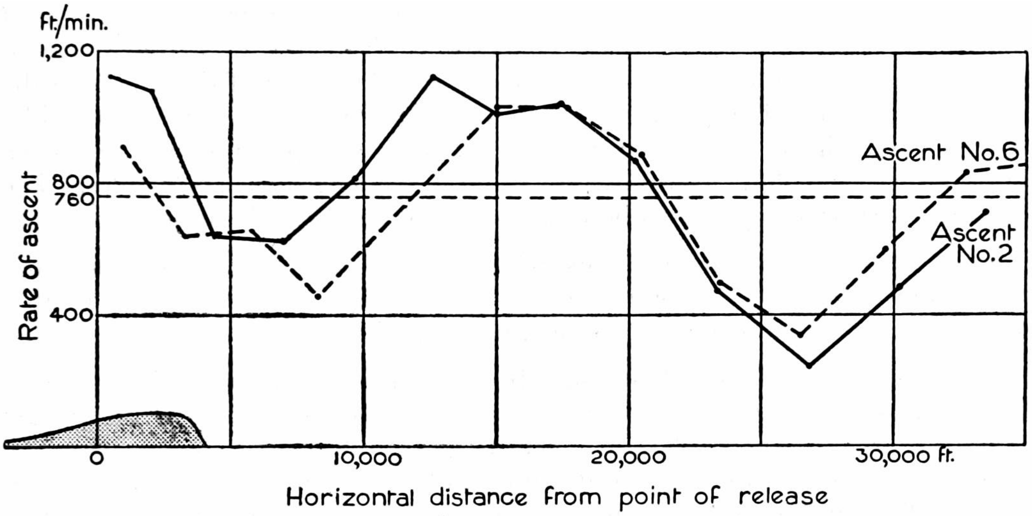
The theory of the formation of condensation trails by aircraft is described in this pamphlet. The most important type of condensation trail is the exhaust trail which forms when the water vapour resulting from combustion of the fuel more than offsets the drying tendency of the heat generated by the engine; this can only occur at low temperatures (below − 11°F. at sea level, below − 34°F. at 30,000 ft.). For a particular height it is important to know the immunity temperature, i.e. the critical temperature above which exhaust condensation trails are unlikely to form even if the atmosphere is saturated. In this second edition of this pamphlet the immunity temperatures for a typical piston-engined aircraft (Spitfire) have been amended in the light of more recent data, and similar figures are also given for a typical jet-engined aircraft (Canberra).

LETTERS TO THE EDITOR

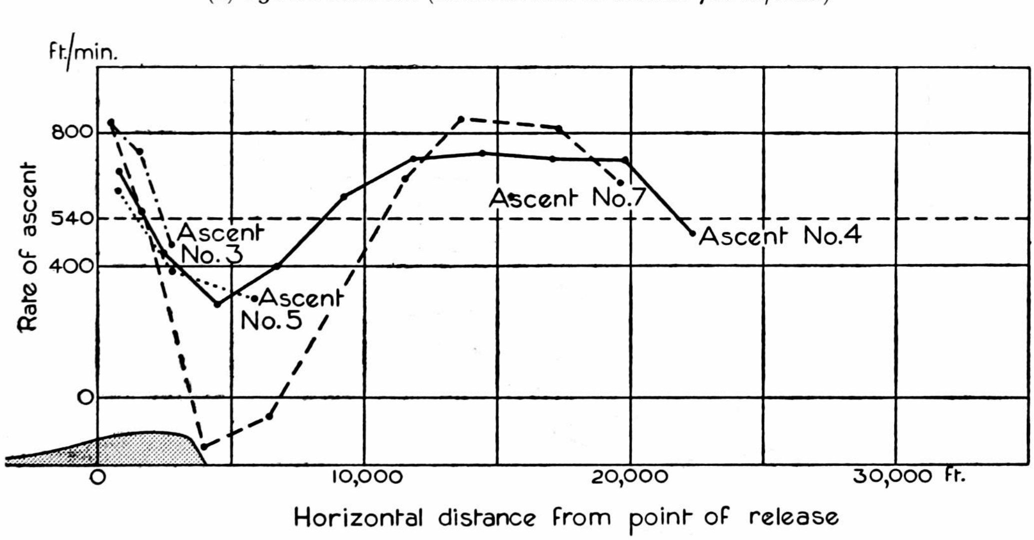
Standing wave at Aberporth

The *Meteorological Magazine* for April 1951 carried a study of standing waves and powered flight[1]. In this, as in similar notes, the lack of quantitative wind measurements was mentioned. It has occurred to me that I may be able to refer you to a good example of reliable wind measurements through a standing wave.

The measurements were made at Aberporth, Cardigan (52°08′N., 04°34′W.) on March 12, 1941, and the regularity of the vertical current was not noticed until later.



(*a*) 150-in. balloons (assumed rate of ascent: 760 ft./min.)



(*b*) 90-in. balloons (assumed rate of ascent: 540 ft./min.)

FIG. 1—PILOT BALLOON ASCENTS FROM ABERPORTH, CARDIGAN

Double theodolite ascents, Nos. 2–7, 1045–1445 G.M.T., March 12, 1941. Wind direction south-easterly, speed 17 kt. at 500 ft., 24 kt. at 5,000 ft. and 28 kt. at 10,000 ft. Height of point of release: 420 ft. above M.S.L. Terrain: approximately level downwind for 4,400 ft. and then a 400-ft. cliff to the sea; upwind, river valleys, main bottom 100 ft. above M.S.L. at 1–1¼ miles, followed by ridge rising to 500–700 ft. above M.S.L. at about 3½ miles

Six ascents (Nos. 2–7 of that date) were made between 1045 and 1445 G.M.T., all by the double-theodolite method, but the balloon behaved so erratically that on two occasions it was accidentally lost from sight by one of the observers after the third minute. Even in these ascents such data as were obtained confirmed the constancy of the phenomenon. Of the four complete ascents, two were made using slightly overfilled 90-in. balloons so that the theoretical rates of ascent were more than 500 ft./min., and two using 150-in. balloons filled to rise at about 750 ft./min.

It was immediately obvious from a comparison of the two pairs of balloons that, as might be expected in a standing wave, the areas of ascending and descending currents depended on horizontal distance from the point of release and were independent of height. A plot of the observed rate of ascent against horizontal distance from the point of release is given in Fig. 1. Observations were made and plotted at one-minute intervals. The inset of the profile of the terrain on the same horizontal scale shows how the first down-draught coincides with the cliff drop. The up-draught at the station is presumably due to the upslope of the valley to windward. The wave-length is 4–4½ miles. The downward currents appear to be more concentrated than the upward ones.

Extreme values of the currents were at least 350 ft./min. upward and 650 ft./min. downward, a total range of 1,000 ft./min. over a distance of half a wave-length. There seemed to be no variation with time.

Small sections of streamlines may be calculated from the balloon ascents if it is assumed that any deviation of the observed increases in height per minute from the estimated rate of ascent in still air is due solely to vertical currents. A rate of ascent of 760 ft./min. has been assumed for ascents 2 and 6 and 540 ft./min. for ascents 4 and 7. Fig. 2 was then constructed as follows.

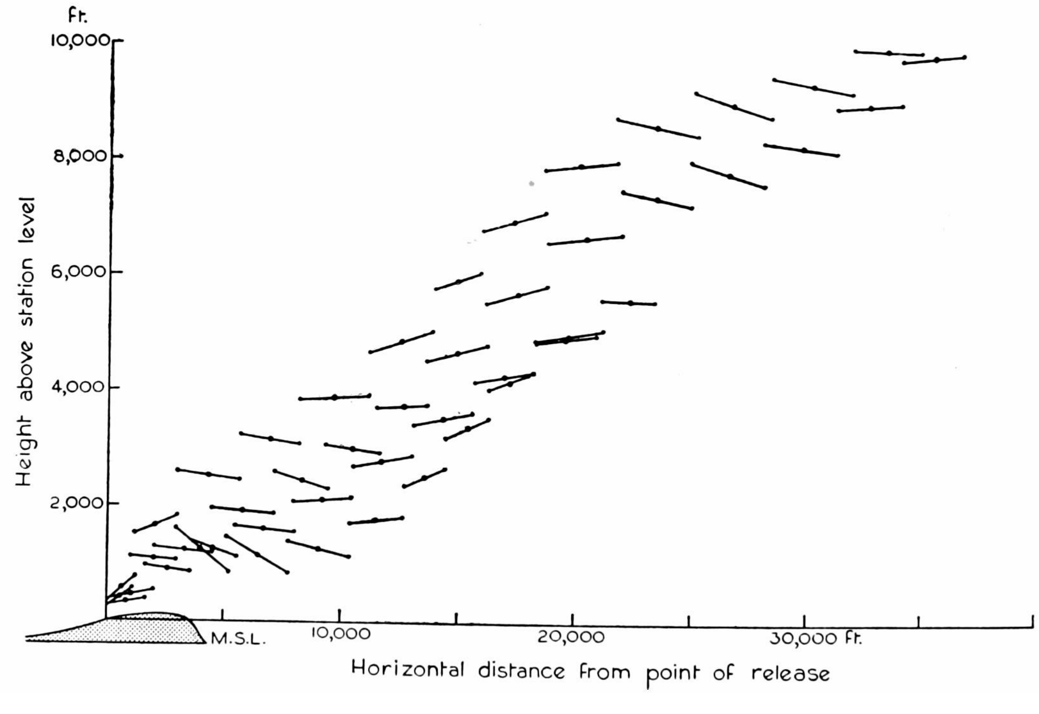


FIG. 2—SECTIONS OF STREAM LINES CALCULATED FROM PILOT-BALLOON ASCENTS

The centre point of each line is the mid height of the balloon above station level in any minute plotted against the mid distance from the station in that minute. The length of the line is the increase of distance from the station in the minute and the difference in height between the ends of the line is the difference between the observed rate of ascent and the estimated rate of ascent in still air. The picture suggested here may be compared with the examples of theoretical streamlines in the lee of an obstruction as given by R. S. Scorer[2].

A. R. LAIRD

Piarco, Trinidad, June 3, 1952

REFERENCES

1. TURNER, H. S.; Standing waves and powered flight. *Met. Mag., London,* **80,** 1951, p. 106.
2. SCORER, R. S.; Theory of waves in the lee of mountains. *Quart. J. R. met. Soc., London,* **75,** 1949, p. 41.

Vertical currents observed at Habbaniya, May 6, 1952

A request from the forecaster on May 6, 1952, for a radar-wind sounding resulted in an ascent being made in very unstable air. The graph in Fig. 1 shows a vertical section of the track of the balloon.

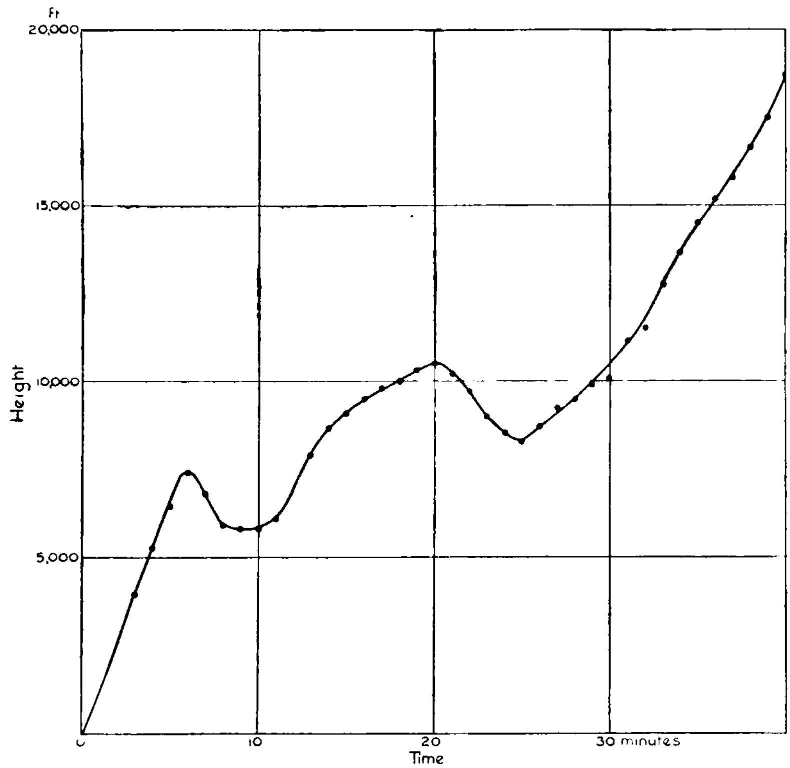


FIG. 1—VERTICAL ASCENT OF RADAR BALLOON AT HABBANIYA, 0630 G.M.T., MAY 6, 1952

Although I have known of balloons being forced down I have never seen a record of one descending so great a distance or for such a length of time. As the balloon was filled to rise at 1,300 ft./min. it will be seen that, with the possible exception of a small period around the 12th minute, the balloon was in a downward current between the 6th and 30th minutes of flight. On two occasions the downward currents were sufficiently strong to force the balloon down through 1,500 ft. The maximum downward current, of the order of 2,100 ft./min., occurred between the 7th and 8th minutes.

The balloon was launched at 0630 G.M.T. The surface wind was 100°, 6 kt. but at 0636 there was a sudden rise to about 16 kt. with a gust of 29 kt. from 330°. The upper wind was about 150°, 15 kt. up to 5,000 ft.; 290°, 6 kt. at 6,000 ft.; 180°, 30 kt. at 8,000 ft.; 200°, 28 kt. at 10,000 ft.; and from there the direction was fairly constant at 190° with the speed increasing to 40 kt. at 20,000 ft.

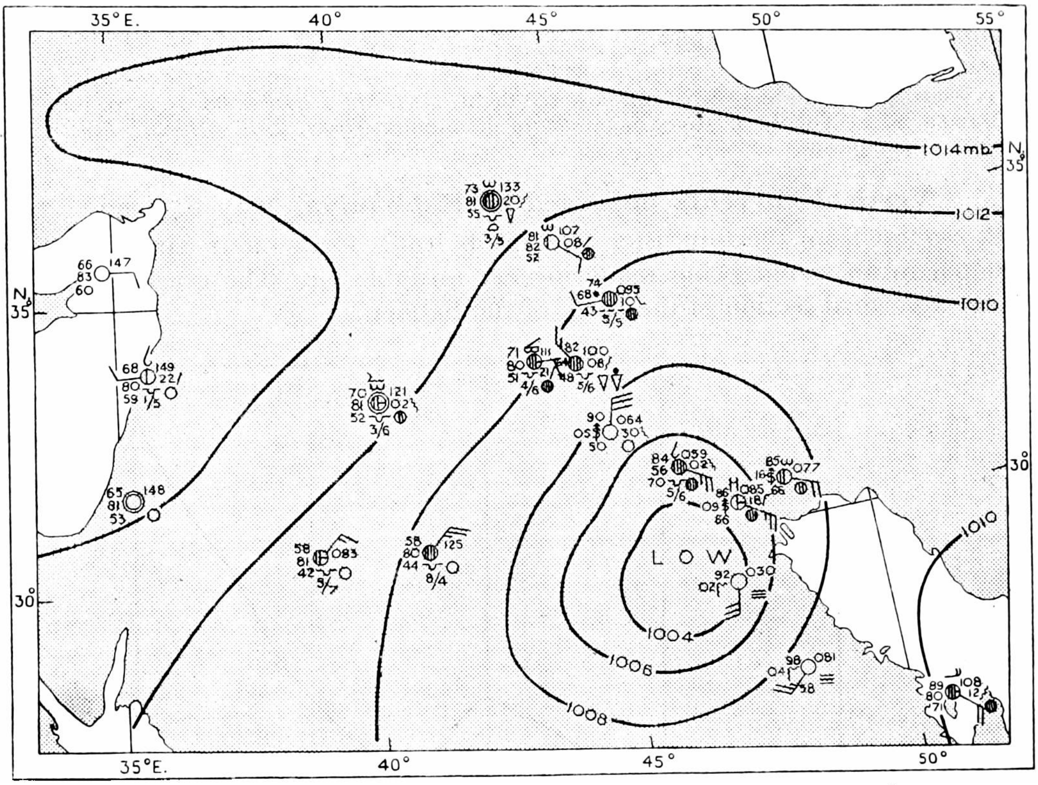


FIG. 2—SYNOPTIC SITUATION, HABBANIYAH, 0600 G.M.T., MAY 6, 1952

At 0630 there were 6 oktas of stratocumulus with base estimated at 5,000 ft. The surface chart for 0600 G.M.T. on May 6 (see Fig. 2) showed a low-pressure system centred at 29°N., 46°E. and the 500-mb. chart for 0300 G.M.T. showed a low-pressure system centred at 35°N., 40°E. From about 0635 G.M.T. there was a drop of about 2 mb. in about 10 min.

H. E. PAINTER

Habbaniya, May 28, 1952

[Venkiteshwaran and Tilakan* describe a more complex occurrence of forced descent of a radio-sonde balloon released at Poona during a thunderstorm on April 26, 1950. On that occasion the fan stopped rotating and the balloon is shown to have been weighted with ice. In the Habbaniya ascent reported by Mr. Painter there seems no doubt that downward currents alone were responsible. Winds calculated on the assumption of constant rate of ascent from observations made in such circumstances would of course be very misleading.—Ed. *M.M.*]

*VENKITESHWARAN, S. P. and TILAKAN, A. R. B.; Interesting features shown by a radio sonde ascent at Poona on 26 April, 1950, during a thunderstorm. *Indian J. Met. Geophys., New Delhi*, 3, 1952, p. 55.

NOTES AND NEWS

Cloud in the stratosphere

In the note on "Very high cloud layer, August 10, 1951", published in the *Meteorological Magazine* for December 1951, a report from a pilot was quoted of a cloud layer between 46,500 and 47,500 ft. near Preston, Lancashire. It was subsequently ascertained that the cloud extended horizontally at least from north of the Welsh mountains to Brighton. It was so tenuous that it was not possible to be exact as to its base or top. Cloud at such a height implied a frost point of between −50° and −58°F., and it is difficult to understand how air with such a frost point could get into the stratosphere above a tropopause (at 37,000 ft.) with a temperature of −70°F.

Trajectories on the isobaric surfaces of 200 and 100 mb. indicated that air at these levels over Liverpool on August 10, might have originated in the region of Hudson Bay two days earlier. The Controller of the Canadian Meteorological Service was asked if there were any reports of forest fires in this region at the relevant time. He replied that it was extremely unlikely that a smoke cloud could have been produced sufficiently coherent to be observable two days later, so far as the relevant Canadian records showed. The pilot who observed the cloud was in a pressurized cabin, using 100 per cent. oxygen so he was unable to express an opinion as to whether the cloud was composed of smoke particles.

Saturation in the stratosphere.—In his letter of reply the Controller of the Canadian Meteorological Service volunteered the opinion that the cloud could have been composed of ice crystals, having regard to the observations of Barrett, Herndon and Carter*. These were upper air observations up to a height exceeding 28 Km., made on July 1 and August 26, 1949, at Camp Ripley, and on January 7, 1950, at St. Louis, and using automatic frost-point hygrometers. All showed a remarkable layer of saturation, with respect to ice, in the stratosphere, at heights between 150 and 100 mb., well above the level of any British frost-point observations. The frost points at the level of saturation were:—

	July 1, 1949	August 26, 1949		January 7, 1950	
			millibars		
Pressure ...	107	138	125	131	116
			degrees Fahrenheit		
Frost point ...	−54	−74	−77	−71	−71

It is impossible to explain how water vapour can be carried upwards in this way, but the authors of the paper after discussing four possibilities conclude that it is most probably due to vertical transport in convection cells, i.e. to the penetration into the stratosphere of very high cumulonimbus.

When the American observations are plotted they are as shown in Fig. 1, where only portions of the curves are given. In or near the layers of saturation in the stratosphere there is a discontinuity in the temperature curve, there being a marked decrease in temperature above the level of the discontinuity as compared with that below the discontinuity. On July 1 the observed point

* BARRETT, E. W., HERNDON, L. R. and CARTER, H. J.; Some measurements of the distribution of water vapour in the stratosphere. *Tellus, Stockholm*, **2**, 1950, p. 302.

of saturation is at the base of the discontinuity, on August 26 there is a layer of saturation at the top of the discontinuity, and on January 7 the layer of saturation is just above the top of the discontinuity. The wet-bulb potential temperatures at the levels of saturation in the later two observations are about or just over 90°F. while that of the first is over 100°F. It is inconceivable that this last observation could relate to the lifting of surface air under adiabatic conditions and the other two observations are very near the borderline in that regard, on the assumption that the relevant air masses originated in the most humid regions of the earth. A possible explanation is that heat by radiation

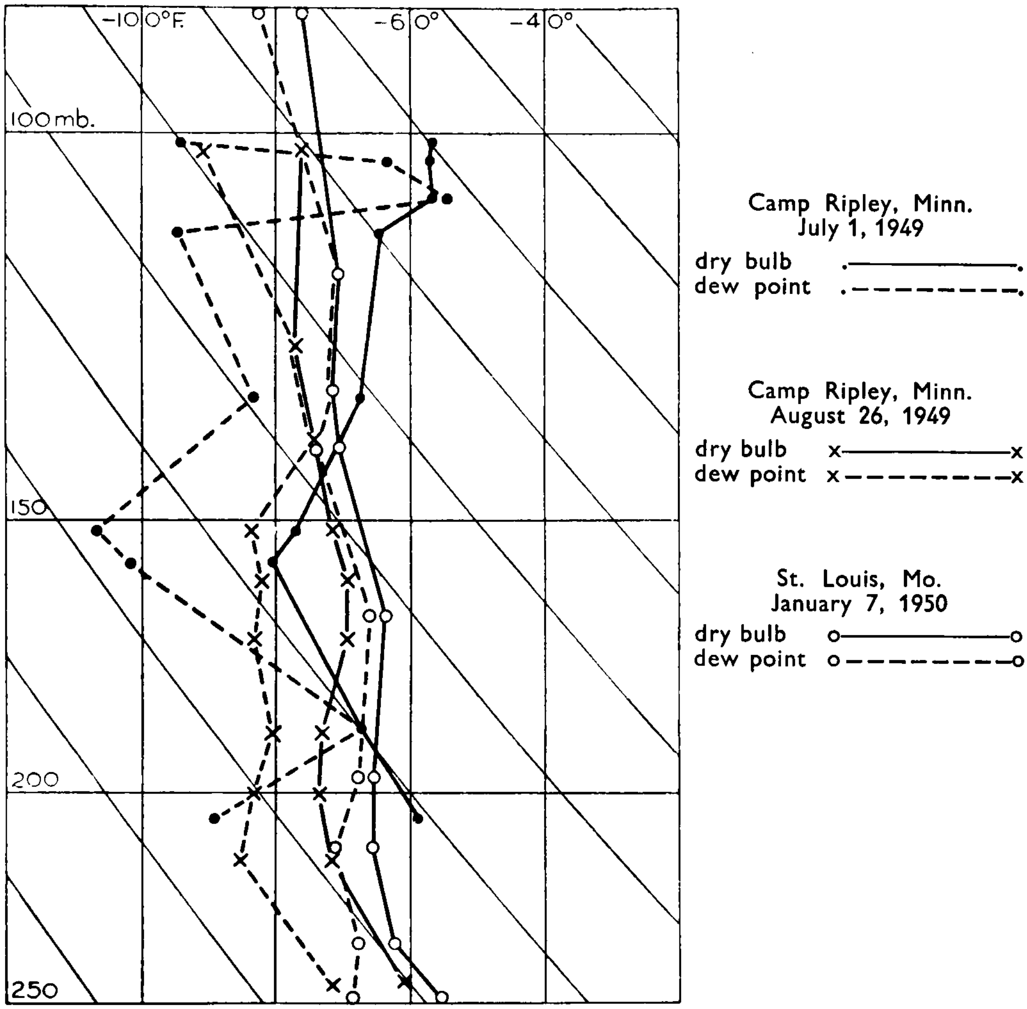


FIG. 1—HIGH-LEVEL TEMPERATURE AND FROST-POINT OBSERVATIONS MADE IN AMERICA

The sloping lines in the background are dry adiabatics

was supplied to the top of a penetrating cumulonimbus cloud, sufficient to evaporate the cloud but insufficient to lower the relative humidity below 100 per cent. One would have expected such a fine adjustment to be rarer than could be encountered on three consecutive chance occasions, but there may be some significance in the fact that the humid layers lay on all occasions between 150 and 100 mb. The authors suggest that such a saturated layer may be a semi-permanent feature of the atmosphere, at least in middle latitudes.

Upper air observations over England and Wales, August 9–10, 1951.—Between 1500 G.M.T. on August 9 and 1500 G.M.T. on August 10, 1951, there was a progressive lifting of the tropopause over Ireland, England and Wales, as shown in Fig. 2. In this figure the isopleths of the change in the pressure level of the tropopause are shown. There is an area of maximum lifting over Wales and south-west England, though the area of absolute maximum lies over north-west France. During the 10th there was a steady encroachment of tropical air in the troposphere over England and Wales, displacing the air of the 9th when there was a pronounced cold pool over the British Isles. The

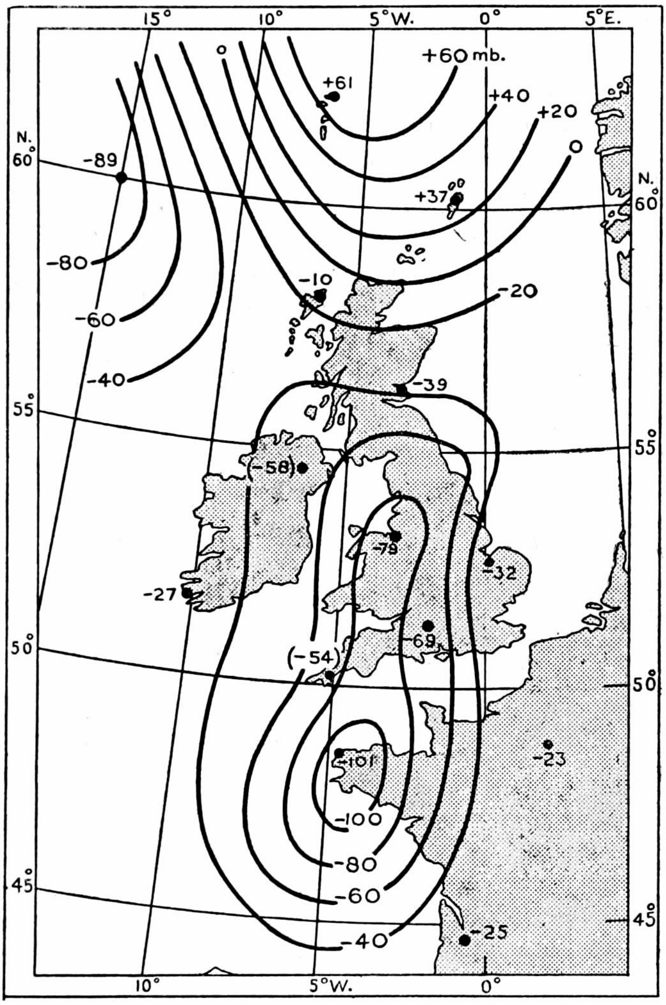


FIG. 2—CHANGE IN LEVEL OF TROPOPAUSE BETWEEN AUGUST 9 AND AUGUST 10, 1951

amount of dry adiabatic lifting required to convert the temperature curve in the stratosphere over Liverpool on the 9th to that over Liverpool on the 10th, would have been approximately that shown in the following table.

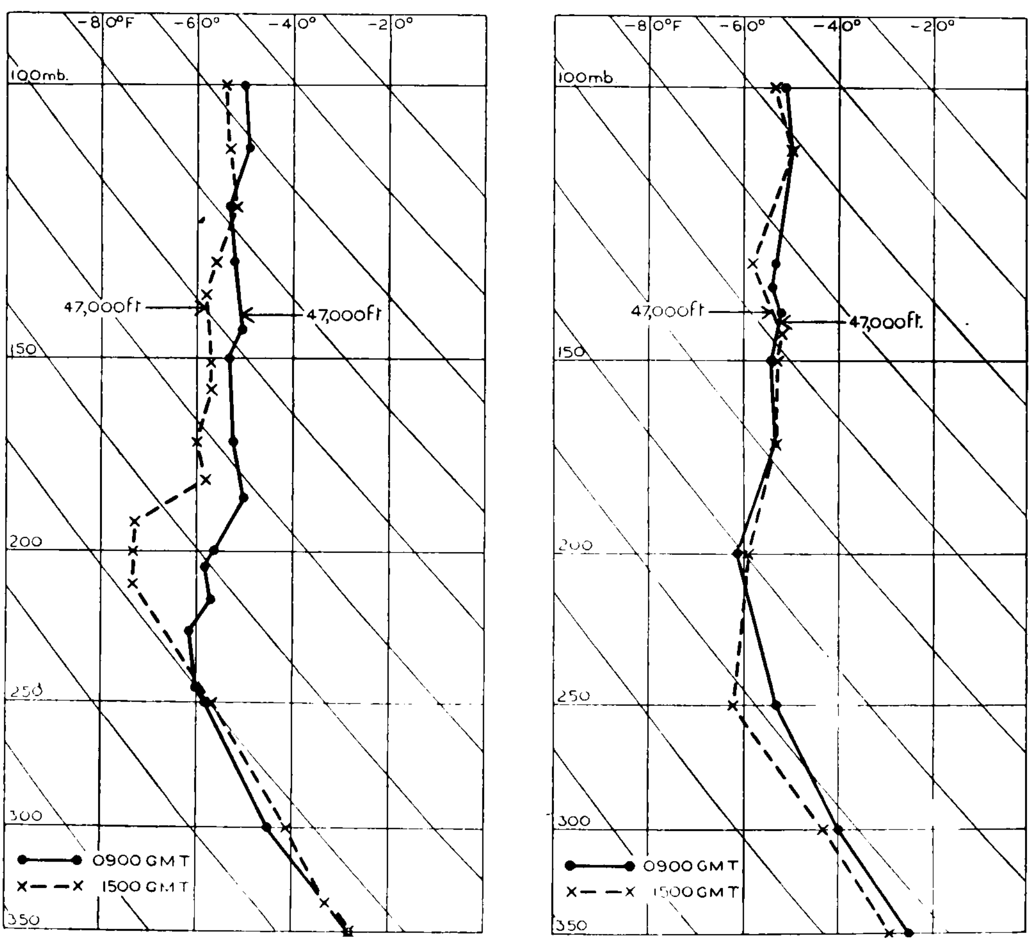
		millibars		
Level of temperature curve { on 9th	277	231	200	160
Level of temperature curve { on 10th	223	203	181	150
Difference between pressure levels (dry adiabatic lifting required)	+54	+28	+19	+10

Examination of the upper air observations over England on August 10 at 0900 and 1500 G.M.T. reveals at a number of stations discontinuities on the temperature curves, in the stratosphere, similar to those shown by the American curves in Fig. 1. One such discontinuity at Liverpool at 0900 G.M.T. occurred between 140 and 135 mb. (about 47,000 ft.) temperature falling 2°F. from the lower to the upper level and the temperature at the base being −52°F. At 1500 G.M.T. this discontinuity had become much more marked, temperature being −52°F. at 144 mb. and −58°F. at 130 mb. Relevant winds were:—

Liverpool	0900 G.M.T.	1500 G.M.T.
150 mb.	338° 30 kt.	316° 27 kt.
130 mb.	336° 22 kt.	318° 19 kt.

These observations show that cooling was occurring throughout the layer within which the cloud formed and at the relevant time. Fig. 3 shows the pressure-temperature curves for Larkhill and Liverpool. These show that the cooling in the stratosphere was more marked at Larkhill than at Liverpool in the period from 0900 to 1500 G.M.T. on August 10, 1951.

An aircraft flying from Edinburgh to Oakington between 0900 and 1000 G.M.T. on Monday, August 25, 1952, observed 8 oktas cirrostratus, base 38,000 ft., top 46,000 ft., over the whole route, the tropopause being at 35,000–36,000 ft. This observation confirms the idea that in disturbed weather



Larkhill | Liverpool

FIG. 3—UPPER LEVELS OF RADIO-SONDE ASCENTS OF AUGUST 10, 1951

The sloping lines in the background are dry adiabatics in summer, vertical movements in the lower stratosphere may lead to condensation in the "semi-permanent layer of saturation" at these heights.

Conclusion.—As indicated in the previous note in the *Meteorological Magazine* the high cloud was the precursor of a vigorous depression associated with prolonged rainfall over the British Isles during a very unsettled period of weather. Probably the intensity of divergence was unusual, and if a saturated layer in the stratosphere between 100 and 150 mb. is a semi-permanent feature of middle latitudes it was probably subject to an unusual degree of cooling. It is suggested that the dynamic cooling of this saturated layer was such as to lead to the cloud observed.

J. S. FARQUHARSON

An example in applied climatology

From inquiries received in the climatological branches of the Meteorological Office it has been apparent for many years that there is an ever-increasing demand for meteorological data for use in industry and other fields of applied science. A first impression from any comprehensive survey of such inquiries must be that their great diversity makes it almost impossible to undertake any concise analysis or exhaustive classification; and this is equally true whether they are looked at mainly with the range of applications in mind, or with the types of data and required methods of presentation to the fore. It also appears that the economic value of the applied data, when this can be assessed with any confidence, bears no consistent relationship to the effort which is needed for their collection and preparation, or to the purely meteorological interest of the information sought.

It follows that the climatologist cannot arrive unaided at any valid conclusions about what can most usefully be done in his field to aid economic development. The needs of the situation can be fully met only by close liaison between climatologists and the appropriate experts in industry and research. This is to some extent realized in present practice; but there is room for an indefinite expansion of what has already been achieved.

An example illustrating these generalizations is furnished by the position regarding information about atmospheric humidity. In the older tradition of climatology emphasis was often placed on relative humidity at the expense of other measures of moisture content, and this was reflected, for instance, in the lay-out of the *Observatories' Year Book*, and in the climatological tables given in various publications. In synoptic meteorology greater emphasis is placed, for obvious reasons, on dew-point temperature. The distribution of vapour pressure has also received attention. But among the more insistent demands in applied climatology there have recently been repeated calls for detailed information about the space-time distribution of wet-bulb temperature. It is not the object of this note to deal with the difficulties of providing this information, from available material, in the form in which it is required, but to discuss two items of current literature[1,2] concerned with a particular field, which explain a great part of the need for wet-bulb temperature data. It will be seen how far some of the general principles which should govern applied climatology can be and are observed.

Wet-bulb temperature data are required mainly in connexion with problems of cooling, air conditioning and comfort, and the literature now under review is concerned with the important sub-section of such problems covering the use of cooling towers in industrial processes. The first item by Jackson[1] is an approach to a general handbook on the subject. The present writer is not competent to discuss the work on the technical side, but finds nothing to conflict with the assurance, given to him by an expert in this field, that it is a very commendable effort containing information of much value, especially with regard to test-data and the economics of cooling. It is perhaps too one-sided in the relative prominence given to one type of tower and to a particular theoretical approach (due to Merkel[3]); against this, however, it is understood that it is the only book of its kind at present available, and it must also be said that its one-sidedness is frankly declared and in part corrected by references to other available literature.

Meteorological interest arises, directly or indirectly, at a number of points:—

(i) the process of evaporative cooling and the importance of atmospheric wet-bulb temperature;

(ii) the quantities of water required in different cooling processes, and the water-supply problem;

(iii) the possible effects, with different processes, on river flow and river temperatures; and

(iv) the possible effects on local atmospheric conditions, including temperature, humidity, visibility and precipitation.

Whilst the greatest interest lies in (i), a few other points connected with (ii) to (iv) may be noted in passing. The water-supply problem (coupled with effects on rivers) is of course a major reason for the existence of cooling towers in that they enable the same water to be used over and over again, with but a small percentage loss for each cycle. With regard to river temperature, an example quoted by Townend and Richards[2] is that throughout the year the Thames is warmer at Battersea than at Teddington (with a difference of about 7°F. in summer), largely, it is supposed, because of the intervening power stations which make direct use of river water for cooling (this supposition probably requires a quantitative check before it can be completely accepted). Finally, the precipitation nuisance in the neighbourhood of cooling towers has been definitely established to be due to the carry-over of spray droplets, and not to condensation as was formerly believed (methods of eliminating it are still under investigation).

On the approach to any meteorological question Jackson's book is weaker than it need be—though perhaps with a deliberate aim. In Appendix B, for example, there appears the statement: "wet-bulb and river-water temperatures are normally approximately equal, but the discharge of hot effluents into rivers in industrial areas raises the temperature of the river water." Evidence for the second part of this statement is given, but not for the first, and examples have been found of river temperatures in non-industrial areas exceeding dry-bulb temperatures (mean values) for part of the year. Although a recent paper by Eckel and Reuter[1] could not have been available to the author at the time of writing, he could surely, with a moment's reflection, have appreciated the role of some of the many factors whose influence these writers discuss.

Similarly, there seems to have been little attempt to find out exactly what information could have been obtained to determine optimum values for design wet-bulb temperatures in different parts of the country. A standard value of 62·8°F. is assumed, "as a reasonable compromise between peak and average summer conditions" (aspirated wet bulb, with dry bulb 68°F. and relative humidity 75 per cent.). It is true that consideration is given to the performance of cooling towers under other atmospheric wet-bulb temperatures, but it is at the design stage that the chosen value is all-important. It would have been useful to supplement the economic comparisons provided in the Appendices with a careful calculation of the saving which would be affected if, for instance, the design wet-bulb temperature could be lowered with confidence from 63°F. to 62°F.

Such information can be obtained from Townend and Richards. Their paper is narrower in its scope but much more satisfactory in its treatment of meteorological and allied data. Some dissatisfaction can be sensed in the statement that "unfortunately, meteorological stations observing wet-bulb temperatures are not numerous in this country" (which should, of course, read "... stations for which data are available in suitable form are not numerous ..."). But the information which has been obtained from the Meteorological Office for six stations near important industrial areas has been most thoroughly and carefully used, and made the basis of important conclusions. It appears that with design wet-bulb temperatures in the neighbourhood of 63–66°F., which are suggested as reasonable values for areas between Glasgow and London, there may well be a saving of 5 or 6 per cent. in the necessary size of a tower, and in corresponding capital costs, for every degree Fahrenheit by which the design wet-bulb temperature can be safely reduced. This surely justifies the authors' contention: "The problem of how often high wet-bulb temperatures occur in various parts of the country and what wet-bulb should be specified to tower makers has not so far received much attention. With modern high-performance mechanical-draught towers, however, it becomes acute". It gives force to the implication that hourly values of wet-bulb temperature should be available for a good number of stations throughout the country in order to meet their desire "to suggest a basis for choosing design wet-bulb temperatures which will enable the process operator to predict how long in an average year any particular water temperature will be exceeded with a given plant or to choose his equipment so that a specified water temperature is only surpassed on a limited number of occasions." The requirement is in fact receiving attention to meet this and other needs.

A. BLEASDALE

REFERENCES

1. JACKSON, J.; Cooling towers with special reference to mechanical draught systems. London, 1951.

2. TOWNEND, F. S. and RICHARDS, R. O.; Cooling water on coking plants. *Gas World, London.* Coking Section Supplement, **39**, 1951, pp. 75.

3. MERKEL, F.; Verdunstungskühlung. *ForschArb. IngWes., Berlin,* Heft 275, 1925.

4. ECKEL, O. and REUTER, H.; Zur Berechnung des sommerlichen Wärmeumsatzes in Flussläufen. *Geogr. Ann., Stockholm,* **32**, 1950, p. 188.

Vertical currents over northern England

A report of vertical currents, apparently associated with lee waves, encountered near Newcastle on November 27, 1951, is published in the *Meteorological Magazine* for May 1952.

Vertical currents were again encountered over Newcastle between 0600 and 0700 G.M.T. on July 11, 1952. The pilot of an aircraft flying on a north-westerly track at 140 kt. at 13,000 ft. encountered an upward current lasting for between 5 and 10 min., which corresponds to a distance of between 14 and 28 miles, of speed estimated at 400–500 ft./min. The speed is estimated from the fact that by maintaining constant altitude airspeed rose from 140 to 160 kt. Down-currents were then experienced for a short period followed by less pronounced up- and down-currents. Another aircraft flying at 10,000 ft. encountered vertical currents producing a rise of air speed from 135 to 165 kt. in the up-currents and a fall to 125 kt. in the down-currents. A third aircraft flying at 13,000 ft., but some 8 miles further east, experienced a slight effect only.

The aircraft were flying over "corrugated" stratocumulus clouds. The tops of the cloud rolls were at 6,000–8,000 ft. and the "valley" bottoms at 3,000–4,000 ft. The corrugations were across the track of the aircraft and apparently roughly along the wind.

The aircraft encountered a wind of 240° 50 kt. at 13,000 ft. The relevant upper wind observations are tabulated below; they are all radar observations. Aldergrove is 170 miles distant to west-south-west, roughly up wind at the time, Liverpool 120 miles to south-south-west and Leuchars 110 miles to north.

	ALDERGROVE				LIVERPOOL		LEUCHARS				
	0300		0900		0900		0300*			0900	
ft.	°	kt.	°	kt.	°	kt.	ft.	°	kt.	°	kt.
24,000	253	52	247	86	256	37	(24,120)	238	61	235	83
18,000	248	46	247	70	255	41	(18,600)	241	63	235	76
14,000	255	44	240	61	254	41	(13,940)	245	57	243	63
10,000	254	47	257	50	247	39	(9,910)	252	58	247	51
6,000	254	40	252	39	252	31	(6,380)	251	43	235	35
2,000	244	25	252	28	243	22	(1,800)	235	33	252	27

* Winds only reported at fixed pressure levels.

It seems probable from these observations that the wind increased with height up to at least 13,000 ft. over Newcastle. The 0300 upper air temperature observations showed the presence of isothermal layers over Aldergrove at 5,000 and 12,000 ft. and of inversions over Liverpool at 3,500 and 8,000 ft. and over Leuchars at 8,000 and 16,000 ft.

The lapse rate above the inversion at 8,000 ft. over Liverpool and Leuchars was small. The increase of wind with height and the presence of the inversions agree with the theoretical requirements for the occurrence of standing waves, but a large lapse rate above the inversion would have been more favourable than the small one. It is however by no means certain that any of these ascents is representative of the temperature over Newcastle at 0600–0700 G.M.T. on July 11, 1952.

REVIEW

Tropical revolving storms and windstorm insurance. By M. C. Hart. *J. chart. Insur. Inst., London,* **48**, 1952, p. 89. *Illus.*, Chartered Insurance Institute, London, 1952. Price: 2*s.*

The literature on insurance against damage on land by wind or precipitation is not large and Mr. Hart's pamphlet, which is written for the instruction of insurance staff, provides, to the meteorologist, an interesting example of the economic importance of meteorological information.

Insurance against damage by hurricanes is a more difficult problem than insurance against fire. Fire claims vary relatively little from year to year; hurricane damage is infrequent but when it does occur produces claims which far exceed the total annual premiums for hurricane insurance.

The pamphlet advises the insurer on the use of meteorological information in the assessment of the liability to damage by hurricanes, tornadoes, strong winds in general, and fire following storm, rain and flood. It is interesting to see that the author, writing in 1948, recommends *Geophysical Memoirs* No. 19 as the most comprehensive study of the incidence of tropical storms*.

G. A. BULL

NEWS IN BRIEF

The L. G. Groves Memorial Prize for Meteorology has been awarded this year to Mr. A. C. Best, M.Sc., Principal Scientific Officer, Meteorological Office, London, who has made a special study of the physical conditions and processes occurring in clouds, and has made important contributions to our knowledge of this subject. Studies have been made of the size-distribution of water droplets in clouds, their rate of coagulation and their rate of evaporation when falling through the atmosphere. The results of these investigations have particular significance in connexion with the development of cloud and fog, the radar detection of cloud and precipitation and the complex problem of ice accretion on aircraft, and are thus of great practical importance to aviation.

Mr. Best's researches provide a coherent picture of a subject which has hitherto been largely a matter of conjecture and uncertainty.

The L.G. Groves Memorial Award for Meteorological Air Observers has been awarded this year to Sergeant J. L. Smith (3039145), Royal Air Force, Meteorological Air Observer, for meritorious work and devotion to duty with No. 1301 Meteorological Flight at Negombo, Ceylon. He has completed over 120 meteorological sorties totalling 660 hours, the majority of the flying having been carried out over sea areas unfrequented by shipping and where navigational aids are very limited. He combined the duties of navigator and meteorological air observer, and displayed technical ability of a high order. His visual observations and his conscientious recording of scientific data have always been of a very high standard, and he has shown a keen appreciation of the forecasters' requirements.

METEOROLOGICAL OFFICE NEWS

Academic successes.—Information has reached us that the following members of the staff have been successful in recent examinations; we offer them our congratulations.

London B.Sc.(Special) pass: W. C. Reynolds

London B.Sc.(General) pass: P. D. Borrett, R. P. Chandler

Intermediate B.Sc.: T. Lockwood.

General Certificate of Education (*Advanced Level*) pass in one, two or three subjects: C. F. Bell, G. F. D. Cooper, S. G. Cornford, D. K. E. Crome, Miss E. A. Harris,

*NEWNHAM, MRS. E. V.; Tropical hurricanes and revolving storms. *Geophys. Mem., London,* **2**, No. 19, 1922.

Miss A. Hart, S. Hunter, E. B. Jefferies, J. N. Lain, P. Menmuir, P. G. Payne, J. A. Smith, M. Waines, R. R. Warner, Miss H. Woods.

Higher National Certificate: S. I. Nute, D. F. Winter.

City and Guilds. Radio I and II: first class pass: A. F. Hope.

Sport and Athletics.—The "Ariel" cricket team, representing the Air Ministry and the Ministry of Civil Aviation, have won the Curtis-Bennett (Cricket) Shield and so become the Civil Service cricket champions of 1952. Messrs. C. L. Hawson (Dunstable) and J. B. Shaw (Victory House) were members of the team.

In the Civil Service swimming championship races Miss D. S. Cook gained third place in the ladies' breast-stroke and Mr. S. W. Lewis third place in the men's 220 yards.

For the second year in succession, the Meteorological Office (Gloucester) team, came third in the Annual Sports of the Gloucester and District Civil Service Association which was held on August 9. Mr. E. B. Jefferies was first in the 120 yards hurdles and second in the 440 yards, in which Mr. Gallimore was third. The veterans, who scored points last year, were most disappointed that no veterans' race was held this year.

Christmas Party.—The Meteorological Office Social and Sports Committee announce that the Christmas Party will be held in the Air Ministry Refreshment Club "B" Block, Adastral House, on Tuesday, December 16. In addition to games and dancing, there will be a one-act play by staff from Harrow.

WEATHER OF SEPTEMBER 1952

Mean pressure was generally below normal over the whole of Europe and above normal over the Atlantic Ocean north of 45°N. The mean pressure in northern Scandinavia fell to 1004 mb., about 8 mb. below normal, and in western Europe where the mean pressure was generally 1015 mb., the deficit of pressure was about 3 mb. Mean pressure at the Azores was normal at 1020 mb., but northwards from the Azores, mean pressure in 50°N. reached 1022 mb. which was 7 mb. above normal and 1018 mb. in 60°N. which was as much as 11 mb. above normal.

Mean temperature was below normal over Europe the deficit generally being 4°F.; the mean temperature varied from 40°F. in Scandinavia, 50–60°F. in west Europe and 65–75°F. in the western Mediterranean.

In the British Isles the month was exceptionally cold for the time of year; at some stations with long records it was the coldest September and at others it equalled the previous cold September of 1912. At Oxford it was the coldest September in a record going back to 1815. It was mainly drier than the average in Ireland, most of Scotland except the north, and in part of the English Midlands and south-west Wales; on the other hand it was very wet in the North and East Ridings of Yorkshire, Dorset and locally on the south-east coast from Calshot to Felixstowe. Sunshine was mostly below the average except in some western districts.

In the opening days of the month pressure was high off our south-west coasts with a ridge extending across France, while a depression off east Iceland moved slowly east and turned north-east. Warm, rather sunny weather prevailed for the most part though showers occurred, chiefly in the north and west. In the early hours of the 3rd a small depression moved across south Scotland giving moderate rain in south Scotland, north England and north Ireland. In the rear of this depression cold northerly winds, with showers and local thunderstorms, prevailed for some days. Slight air frost occurred locally in Scotland and Ireland on the 7th and ground frost occurred fairly widely even in the south in the early morning on the 6th, 7th and 8th, while the maximum temperature at Dunstable on the 7th was only 47°F. On the 7th a shallow depression formed over the western English Channel and moved east causing widespread thunderstorms in the south (2·49 in. of rain was registered at Deal Water Works). Subsequently a depression north of the Faeroes moved south over the western part of Great Britain giving considerable rain, particularly in the south-west (3·09 in. at Beaminster, Dorset, on the 9th). Further rain or showers occurred in England and Wales on the 11th and 12th. Meanwhile an anticyclone was situated off our north-west coasts, and this system maintained dry weather over most of the country from the 13th to the 15th. On the 16th a depression near Iceland moved east to west Norway and by the 17th cold northerly winds were renewed over the British Isles, with showers and bright periods. There was more ground frost on the mornings of the 18th to the 20th. On the 20th and 21st a depression off south-east Iceland moved east-south-east, while a trough moved south-east over the British Isles giving rain generally, but on the 22nd and 23rd an anticyclone off our south-west coasts was associated with a short fair spell over England and Wales, temperature reaching 70°F. locally on the 23rd. On the 24th a very deep depression approached north-west Scotland and on the 25th it moved east-south-east to the North Sea. Heavy rain fell locally in Scotland on the 23rd and more widely on the 24th and 25th, while rain or showers occurred on the 26th (3·98 in. at Erracht, Glenhoy on the 23rd, 3·67 in. at Glenquoich on the 24th, 3·60 in. at Kinlochquoich and 2·39 in. at Thirlmere, Cumberland, on the 25th, and 3·65 in. at Kinlochquoich on the 26th). Gales were recorded at exposed stations especially in the west and north on the 24th to 26th and strong winds were general. Behind this depression north-westerly winds again prevailed and cool, unsettled weather was maintained until the end of the month. A depression moved north-east over England on the 28th and 29th; rainfall was heavy in places (2·28 in. at Kildale Gardens, Yorkshire, on the 28th) and thunder occurred locally. Another depression over Brittany on the 30th moving north-east gave widespread and prolonged rain in the south.

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 ...	75	27	−3·9	148	+5	86
Scotland	69	27	−3·2	98	+1	91
Northern Ireland ...	68	30	−3·7	74	+1	92

RAINFALL OF SEPTEMBER 1952

Great Britain and Northern Ireland

County	Station	In.	Per cent. of Av.	County	Station	In.	Per cent. of Av.
London	Camden Square ...	2·76	152	*Glam.*	Cardiff, Penylan ...	4·53	149
Kent	Folkestone, Cherry Gdn.	5·13	216	*Pemb.*	Tenby, The Priory ...	2·45	78
,,	Edenbridge, Falconhurst	3·15	139	*Radnor*	Tyrmynydd	4·48	116
Sussex	Compton, Compton Ho.	4·43	159	*Mont.*	Lake Vyrnwy	4·10	114
,,	Worthing, Beach Ho. Pk.	4·60	215	*Mer.*	Blaenau Festiniog ...	8·89	113
Hants.	Ventnor Cemetery ...	5·20	205	,,	Aberdovey	2·56	80
,,	Southampton, (East Pk.)	3·92	180	*Carn.*	Llandudno	3·86	181
,,	Sherborne St. John ...	3·48	170	*Angl.*	Llanerchymedd ...	4·49	153
Herts.	Royston, Therfield Rec.	3·12	166	*I. Man*	Douglas, Borough Cem.	4·28	131
Bucks.	Slough, Upton... ...	3·06	174	*Wigtown*	Newton Stewart ...	2·86	84
Oxford	Oxford, Radcliffe ...	1·68	98	*Dumf.*	Dumfries, Crichton R.I.	1·62	60
N'hants.	Wellingboro' Swanspool	2·33	129	,,	Eskdalemuir Obsy. ...	2·35	64
Essex	Shoeburyness	3·50	210	*Roxb.*	Kelso, Floors	2·26	119
,,	Dovercourt	4·48	250	*Peebles*	Stobo Castle	2·18	87
Suffolk	Lowestoft Sec. School...	2·79	142	*Berwick*	Marchmont House ...	2·43	101
,,	Bury St. Ed., Westley H.	2·73	137	*E. Loth.*	North Berwick Res. ...	1·95	93
Norfolk	Sandringham Ho. Gdns.	3·35	162	*Midl'n.*	Edinburgh, Blackf'd. H.	1·88	92
Wilts.	Aldbourne	2·36	118	*Lanark*	Hamilton W. W., T'nhill	2·36	88
Dorset	Creech Grange... ...	6·55	239	*Ayr*	Colmonell, Knockdolian	2·83	82
,,	Beaminster, East St. ...	6·58	258	,,	Glen Afton, Ayr San. ...	2·93	75
Devon	Teignmouth, Den Gdns.	2·81	143	*Renfrew*	Greenock, Prospect Hill	4·43	99
,,	Cullompton	3·48	155	*Bute*	Rothesay, Ardencraig...	3·39	84
,,	Ilfracombe	3·59	133	*Argyll*	Morven (Drimnin) ...	5·00	88
,,	Okehampton Uplands...	5·00	154	,,	Poltalloch	5·27	115
Cornwall	Bude, School House ...	3·32	134	,,	Inveraray Castle ...	5·96	93
,,	Penzance, Morrab Gdns.	4·29	146	,,	Islay, Eallabus... ...	3·78	90
,,	St. Austell	5·11	160	,,	Tiree	3·45	93
,,	Scilly, Tresco Abbey ...	4·67	182	*Kinross*	Loch Leven Sluice ...	2·46	96
Glos.	Cirencester	1·43	65	*Fife*	Leuchars Airfield ...	0·77	40
Salop	Church Stretton ...	2·53	120	*Perth*	Loch Dhu	4·55	79
,,	Shrewsbury, Monksmore	1·41	87	,,	Crieff, Strathearn Hyd.	1·37	48
Worcs.	Malvern, Free Library...	1·29	67	,,	Pitlochry, Fincastle ...	1·12	45
Warwick	Birmingham, Edgbaston	1·74	97	*Angus*	Montrose, Sunnyside ...	0·89	45
Leics.	Thornton Reservoir ...	1·64	91	*Aberd.*	Braemar	1·73	69
Lincs.	Boston, Skirbeck ...	2·21	126	,,	Dyce, Craibstone ...	2·05	85
,,	Skegness, Marine Gdns.	2·67	148	,,	New Deer School House	4·22	167
Notts.	Mansfield, Carr Bank...	1·98	108	*Moray*	Gordon Castle	3·93	157
Derby	Buxton, Terrace Slopes	4·61	142	*Nairn*	Nairn, Achareidh ...	1·50	71
Ches.	Bidston Observatory ...	3·70	154	*Inverness*	Loch Ness, Garthbeg ...	3·96	128
,,	Manchester, Ringway...	2·88	127	,,	Glenquoich	11·87	137
Lancs.	Stonyhurst College ...	5·13	134	,,	Fort William, Teviot ...	6·37	100
,,	Squires Gate	4·61	170	,,	Skye, Duntuilm ...	5·82	127
Yorks.	Wakefield, Clarence Pk.	1·45	91	,,	Skye, Broadford ...	7·08	102
,,	Hull, Pearson Park ...	3·63	211	*R. & C.*	Tain, Tarlogie House ...	1·32	58
,,	Felixkirk, Mt. St. John...	4·23	232	,,	Inverbroom, Glackour...	6·30	143
,,	York Museum	3·72	228	,,	Achnashellach	9·34	136
,,	Scarborough	5·33	298	*Suth.*	Lochinver, Bank Ho. ...	6·14	177
,,	Middlesbrough... ...	4·66	281	*Caith.*	Wick Airfield	2·45	98
,,	Baldersdale, Hury Res.	3·60	141	*Shetland*	Lerwick Observatory ...	4·03	134
Norl'd.	Newcastle, Leazes Pk....	3·51	177	*Ferm.*	Crom Castle	1·50	54
,,	Bellingham, High Green	3·06	127	*Armagh*	Armagh Observatory ...	1·23	50
,,	Lilburn Tower Gdns. ...	4·31	183	*Down*	Seaforde	1·63	59
Cumb.	Geltsdale	3·88	139	*Antrim*	Aldergrove Airfield ...	1·39	56
,,	Keswick, High Hill ...	6·01	142	,,	Ballymena, Harryville...	2·90	93
,,	Ravenglass, The Grove	3·05	91	*L'derry*	Garvagh, Moneydig ...	3·49	117
Mon.	Abergavenny, Larchfield	3·28	140	,,	Londonderry, Creggan	3·35	102
Glam.	Ystalyfera, Wern House	3·09	71	*Tyrone*	Omagh, Edenfel ...	1·78	58