Met.O.801
METEOROLOGICAL OFFICE

the meteorological magazine

JUNE 1968 No 1151 Vol 97
Her Majesty's Stationery Office

Handbook of weather messages, Part II

5th edition

Recommendations which were made by the Commission for Synoptic Meteorology in April 1966, and which were approved by the Executive Committee of the World Meteorological Organization at Geneva in July 1966, necessitated changes in some of the code forms and specifications to be used in surface and upper air reports, forecasts and analyses from 1 January 1968. This new edition of the *Handbook of weather messages, Part II* incorporates these changes.

15*s*. 6*d*. (by post 16*s*. 3*d*.)

Published by
HER MAJESTY'S STATIONERY OFFICE
and obtainable from the Government Bookshops in London (post orders to P.O. Box 569, S.E.1), Edinburgh, Cardiff, Belfast, Manchester, Birmingham and Bristol or through any bookseller

METEOROLOGICAL OFFICE Met.O.801

THE METEOROLOGICAL MAGAZINE

Vol. 97 No. 1151, June 1968

551.509.323 551.509.53

COMPARISON OF METHODS OF FORECASTING NIGHT-MINIMUM TEMPERATURES

By J. GORDON and S. E. VIRGO, O.B.E.

Introduction. Three methods of forecasting night-minimum temperature are discussed in this article:

(i) Craddock and Pritchard's method,[1] which is a statistical method based on a regression equation.

(ii) McKenzie's method,[2] which depends on evaluating the constant C for various cloud amounts and wind speeds in the formula

$$T_{min} = \tfrac{1}{2}(T_{max} + D) + C$$

where T_{max} is the day maximum temperature and D is a forecast of the average dew-point of the air expected during the night.

(iii) A method due to Saunders,[3,4] which depends on forecasting the night cooling curve under standard conditions and then applying corrections for cloudiness and other factors.

Initial comparison of three methods. There were two main stages in this investigation. The work of Craddock and Pritchard was wholly statistical, based on observations from 16 stations in the Midlands, and the authors pointed out that theirs was not so much a method as a yardstick by which other methods could be judged; they said 'there is no reason to devote time to developing any method which does not, on preliminary trial, offer advantages in accuracy or ease of use when compared with this datum'. The first stage of the investigation was, therefore, concerned with comparing the methods of Saunders and McKenzie against this yardstick. Comparisons were made at 13 stations for the winter period October 1963 – March 1964. The stations are listed in Table I. Tinney and Menmuir[5] had constructed curves for the winter season for each of these stations, based on 2 years' observations, and these were used as the basis of the test of the method due to Saunders; but refinements were later made on the basis of 4 years' observations.

Out of 47 United Kingdom forecasting offices which have stated that they use McKenzie's method, 37 use his original table of constants calculated for Dyce. When, however, the tables of constants which had been calculated for other stations were compared, it was found that by an accident of good fortune, McKenzie's constants for Dyce are roughly the average of constants which have been calculated for other stations. Since McKenzie's constants are so widely used, it was decided to use them in the first stage of the present

TABLE I—COMPARISON OF RESULTS OF FORECASTING NIGHT-MINIMUM TEMPERATURE BY THREE METHODS FOR THE PERIOD OCTOBER 1963 – MARCH 1964

Station	No. of cases	Craddock and Pritchard		McKenzie*		Saunders†	
	n	$\Sigma(d/n)$	$\sqrt{\Sigma(d^2/n)}$	$\Sigma(d/n)$	$\sqrt{\Sigma(d^2/n)}$	$\Sigma(d/n)$	$\sqrt{\Sigma(d^2/n)}$
		degrees Celsius					
Bassingbourn	70	1·2	2·4	0·4	1·6	−0·2	1·2
Cottesmore	68	0·4	1·9	0·3	1·3	0·3	1·7
Finningley	50	0·6	3·5	0·3	2·0	0·1	0·9
Gaydon	42	1·5	2·7	1·0	2·1	0·7	1·6
Honington	54	1·4	2·6	0·9	2·2	0·7	2·2
Lindholme	42	1·2	2·5	0·2	1·8	−0·3	1·5
Marham	55	1·3	2·4	1·2	2·7	0·1	1·9
Mildenhall	78	1·1	2·9	0·1	2·0	0·8	2·0
Scampton	55	1·1	2·4	0·3	1·3	0·0	1·1
Waddington	75	1·0	2·0	0·2	1·6	−0·1	1·6
Wittering	97	0·6	2·0	0·3	1·7	0·0	1·6
Wyton	86	1·3	2·3	1·6	2·5	−0·5	1·5
Watton	60	1·3	2·3	1·2	2·4	0·3	1·9

$d = F - A$, where A is the actual minimum temperature observed on a particular night and F is the forecast value obtained by the particular method in use.
n = Number of cases.
* As for Dyce.
† Adapted to each station.

investigation, even though the stations in the present test are all at latitudes very different from that of Dyce and have different topography. (McKenzie's original constants were converted for use with the Celsius scale.) Nights without precipitation or change of air mass were used for the test, and the 'forecast' was made in arrears to eliminate errors in forecasting wind and cloud amount.

In Table I, which shows the results of the comparison, n is the number of cases and $d = F - A$, where A is the actual minimum temperature observed on a particular night and F is the forecast value obtained by the particular method in use.

The mean error $\Sigma(d/n)$ ideally should be 0·0 in every case. On average it is about + 1·0 degC for method (i) (Craddock and Pritchard), much smaller (about + 0·5 degC) for method (ii) (McKenzie), and very small indeed (about + 0·1 degC) for method (iii) (Saunders).

The root-mean-square error, $\sqrt{\Sigma(d^2/n)}$ is a measure of the scatter. This is largest for Craddock and Pritchard, much less for McKenzie and in most cases still less for Saunders.

Table I shows that methods (ii) and (iii) come out well when measured against the yardstick of Craddock and Pritchard's method, and it also suggests that McKenzie's method would give even better results if tables of constants were devised for individual stations.

Errors in McKenzie's method arising from errors in forecasting three parameters. The errors, shown in Table I, in forecasting the minimum temperature were all found by using actual values of the predictors. An analysis was therefore made, at 6 stations, of the mean errors in forecasting each predictor during the spring of 1965. It was assumed that the maximum temperature would be known at the time that the minimum temperature had to be forecast, so the predictors to be forecast by McKenzie's method

TABLE II—TABULATION OF FORECAST ERRORS IN McKENZIE'S METHOD

Station	Period 1965	No. of cases	Average errors in *D* degC	*NL* oktas	*ff* knots
Mildenhall	Feb. —June	125	1·1	1·7	2·4
Honington	Feb. —June	70	1·1	1·8	2·3
Marham	Feb. —June	82	0·9	1·4	2·0
Wittering	Mar. —June	72	0·9	1·1	2·4
Watton	Mar. —June	69	1·4	1·8	2·4
Gaydon	Mar. — May	25	1·3	1·3	3·2
Mean errors			1·1	1·5	2·5

Total number of cases 443

D = Nightly average of dew-point.
N_L = Nightly average of low cloud amount.
ff = Nightly average of wind speed.

were the nightly averages of dew-point, cloud amount and surface wind. The errors in forecasting these 3 elements are shown in Table II.

The mean error of 2·5 kt in the forecast of the surface wind introduces an error in McKenzie's '*C*' which is not constant but is likely to be considerably less than 1 degC.

The mean error of 1·1 degC in the forecast of the dew-point introduces an error in the forecast minimum temperature of 0·5 degC at all times.

The mean error of 1·5 oktas in the cloud amount introduces a variable error into the forecast; with much wind and cloud it is as low as 0·5 degC and with light winds and clear skies it is as high as 2·5 degC.

Thus, in using McKenzie's formula, the greatest errors are likely to arise from a wrong forecast of cloud amount, the forecast of dew-point introduces a smaller average error, and the error in surface wind forecast is likely to be the smallest contribution to the error in a forecast. Nevertheless, it must not be overlooked that the predictors themselves are not independent. For example, an underestimate of the cloud amount may well be accompanied by an underestimate of the wind speed.

Test for Mildenhall. It is now appropriate to discuss the second main stage of this investigation. After the work described above had been completed, Tinney and Menmuir were able to refine their curves for winter and summer by basing them on observations for 4 years instead of 2 years. It was then decided to construct a table of McKenzie's constants specifically for Mildenhall and to compare forecasts based on this table with those using the method of Saunders and the curves for Mildenhall produced by Tinney and Menmuir.

The construction, from 4 years data, of a table for McKenzie's method for Mildenhall, proved to be a very onerous task. Data were extracted from *Daily Registers* covering the 16 years from 1949 to 1964 and a total of 704 suitable occasions were found for evaluation of *C*. The final table, Table III, was then used for a comparison of the two methods for the period of 13 January 1966 to 12 January 1967, when 1 year's data had been accumulated. Unlike the first stage of the investigation this was a true forecasting test done with real forecasts before the event. The distribution of errors about the mean was a fair approximation to a normal distribution for both methods, and the root mean square errors were as follows :

Method (iii) (Saunders) 2·16
Method (ii) (McKenzie) 2·09.

These figures show that, as far as accuracy is concerned, there is very little to choose between the methods when applied to Mildenhall. McKenzie's method is quick to handle and is recommended on that account, provided that the tedious initial groundwork of compiling a complete table of McKenzie's constants has been done. The method due to Saunders, on the other hand, provides a cooling curve from which temperatures at other times during the night could be estimated if needed.

Month-by-month comparisons showed that in May, June, August and September method (iii) (Saunders) gave slightly better results, though for the year as a whole method (ii) (McKenzie) proved slightly more accurate. (July was a bad month for both methods.) This might mean that McKenzie's method is more reliable in the winter half of the year, but considerably more testing would be necessary to establish this fact conclusively. It is interesting to note that Schmidt,[6] who studied the forecasting of minimum temperatures at Warnemünde, a coastal station on the Baltic, reached the conclusion that the best method at one time of year may not be the best method at another time.

TABLE III—VALUES OF McKENZIE'S CONSTANT FOR MILDENHALL

Average surface wind speed	Average low cloud cover in oktas 0	2	4	6	8
knots			*degrees Celsius*		
Calm	−7·1	−5·3	−5·3	−3·9	−3·9
1 − 3	−5·8	−4·7	−4·7	−3·2	−2·3
4 − 6	−5·1	−4·7	−3·8	−2·3	−0·9
7 − 10	−4·7	−3·8	−2·9	−2·3	−0·9
11 − 16	−3·8	−2·9	−1·3	−0·9	−0·7
17 − 21	−2·3	−1·3	−1·3	−0·9	−0·7
22 − 27	−1·3	−0·9	−0·9	−0·9	−0·7

Examination of daily results shows that when large errors occurred they were usually common to both methods; in other words, some unexpected development caused erroneous forecasts by both methods. On the other hand it sometimes happened that when McKenzie's method gave an exact forecast there was a sizable error in the forecast given by the method due to Saunders, and vice versa.

Acknowledgements. The co-operation of forecasters at Mildenhall and the 12 other stations concerned in the various stages of the investigations is gratefully acknowledged. Without their assistance and interest the data required could not have been amassed and the tests could not have been made.

REFERENCES

1. CRADDOCK, J. M. and PRITCHARD, D.; Forecasting the formation of radiation fog — a preliminary approach. (Unpublished, copy available in the Meteorological Office Library, Bracknell.)
2. McKENZIE, F.; A method of estimating night minimum temperatures. (Unpublished, copy available in the Meteorological Office Library, Bracknell.)
3. SAUNDERS, W. E.; Night cooling under clear skies. *Q. Jnl R. met. Soc., London*, **75**, 1949, p. 154.
4. SAUNDERS, W. E.; Some further aspects of night cooling under clear skies. *Q. Jnl R. met. Soc., London*, **78**, 1952, p. 603.
5. TINNEY, E. B. and MENMUIR, P.; Results of an investigation into forecasting night-minimum screen temperatures. *Met. Mag., London*, **97**, 1968, p. 165.
6. SCHMIDT, K.-H.; Ein Beitrag zur Vorhersage der Temperaturminima in Nächten mit geringer Bewölkung. *Zeit. Met., Berlin*, **14**, 1960, p. 297.

551.509.323 551.509.53

RESULTS OF AN INVESTIGATION INTO FORECASTING NIGHT-MINIMUM SCREEN TEMPERATURES

By E. B. TINNEY and P. MENMUIR

Object of the investigation. Saunders published his method of forecasting a radiation-night screen temperature curve in 1949 and applied it to three stations in southern England.[1,2,3] Several other investigators, including Parry,[4] Roberts,[5] Bruce[6] and Barthram[7] have applied it to other stations with good results, but these were all individual investigations at different times over different periods. In order to provide working tools for forecasters, temperature data for the period October 1961–September 1965 were analysed for each of 13 stations in eastern England and the Midlands. (The positions of the stations and their heights above sea level are shown in Figure 1.) The observations were scrutinized for consistency with neighbouring stations and doubtful cases were referred back to the stations concerned.

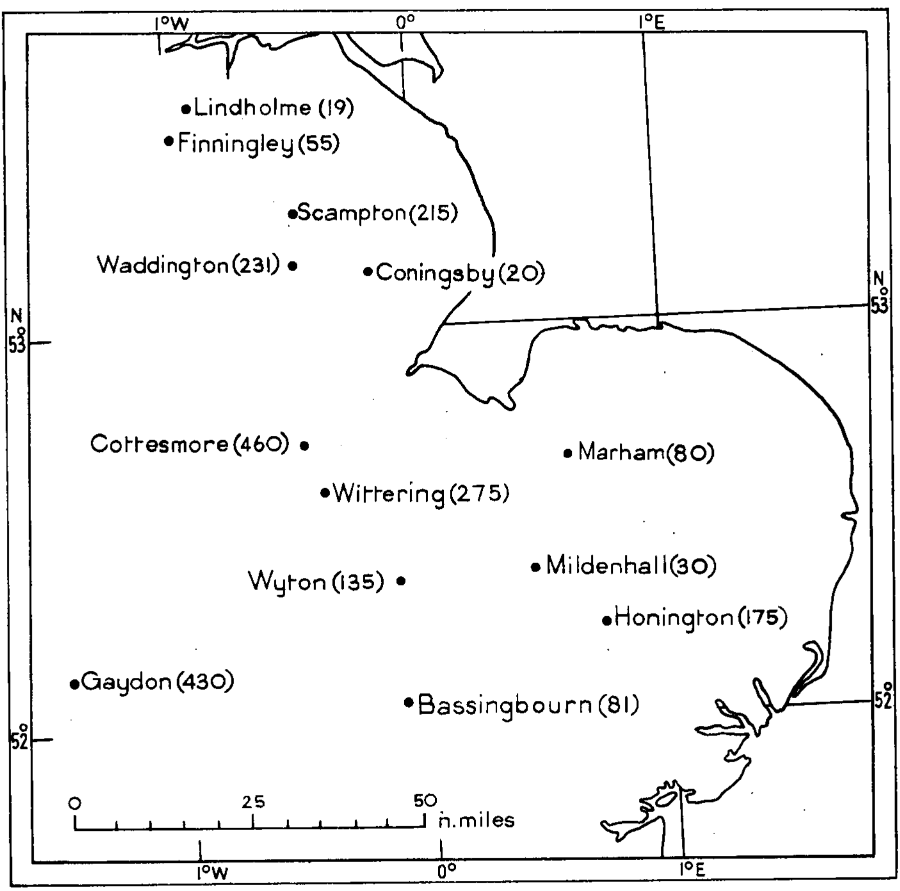


FIGURE 1—POSITIONS OF STATIONS
The bracketed numbers are heights above MSL in feet.

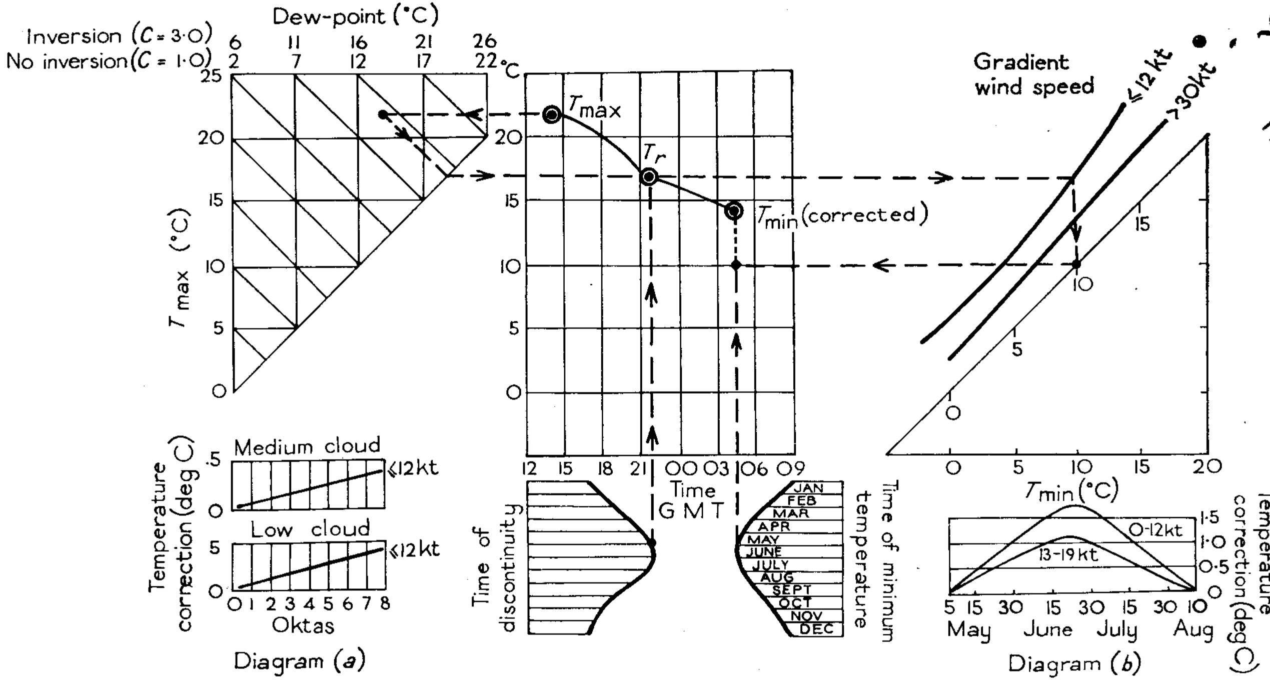


FIGURE 2—DIAGRAM FOR FORECASTING A COOLING CURVE

Example: date 30 May, $T_{max} = 22°C$, $T_d = 14°C$, no inversion, wind speed = 10 kt, cloud cover 6/8 low cloud, T_{min} (nil cloud) = 10°C, T_{min} corrected for cloud and reduced cooling = 14°C.

Note. For clarity only two ranges of gradient wind speed are shown.

Diagram (*a*) — correction to T_{min} for average cloud amount (see also Figure 4).
Diagram (*b*) — correction for reduced length of subsequent cooling (see also Figure 5).

Barthram[7] has described a diagram which provides an easy way of doing the calculations and has given instructions for its use. His diagram serves as the basis for the present work, and the observations were used to construct individual curves for each of the stations concerned.

Most previous investigations have been confined to radiation nights; this investigation covers nights with any cloud cover between nil and 8/8, provided there was no precipitation and no change of air mass during the night. About 14 000 high-quality observations were used in the investigation.

Barthram's diagram and the basis of the method due to Saunders. The diagrams supplied to forecasters taking part in the investigation are essentially in the same format as Barthram's diagram,[7] with one or two refinements which will be described. The diagrams are on sheets of paper 23 in × 13 in and are covered with perspex so that each night's cooling curve can be drawn and then rubbed off after it has served its purpose. A reduced version of the combined diagram with some of the detail omitted is shown in Figure 2. In the actual diagrams the temperature grid is in 1 degC intervals on a scale of 5 degC to the inch. A typical cooling curve is shown in the middle section of the diagram.

It will be recalled that Saunders in his original paper[1] based his method on identifying a discontinuity in the cooling curve at some temperature T_r at some time after sunset. It is not possible to identify this discontinuity on every occasion and Saunders subsequently derived T_r from a regression equation of the form

$$T_r = \tfrac{1}{2}(T_{\text{max}} + T_d) - C$$

where T_d is the dew-point at the time of maximum temperature T_{max} and C is a constant which depends upon the site, the presence or absence of an afternoon inversion below 900 mb, and the cloud cover between the times of occurrence of T_{max} and T_r. Cooling from T_r to T_{min} depends on the gradient wind, and curves for two ranges of gradient wind appear on the right-hand side of the diagram. Other authors have used the geostrophic wind but the difference between the two is probably of little consequence.

As Barthram has described the method of using the diagram, this will not be repeated here, but the salient features of the present investigation are discussed below.

Diagram showing times of change in rate of cooling. The graphical method of determining T_r devised by Barthram was to construct a subsidiary graph showing the variation of time of the discontinuity with time of year and to enter the main diagram by rising vertically from the appropriate point on this curve. Although Barthram had drawn this curve, it was recalculated using data when T_r could be identified on the thermogram for nights with less than 2/8 cloud cover for all stations for two complete years (approximately 1200 observations) and the final curve, not very different from Barthram's, is shown in Figure 3; the time of T_{min} is also included. As all the stations lie close to the Greenwich meridian, no adjustment is necessary for longitude.

In general, the temperature T_r occurs about $1\tfrac{3}{4}$ hours after sunset from April to October inclusive, and about $1\tfrac{1}{4}$ hours after sunset from November to March, although at one station, Marham, T_r occurred about $\tfrac{3}{4}$ hour after

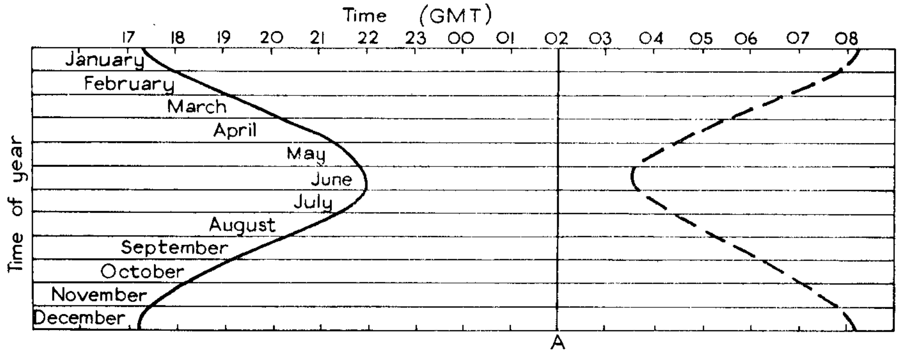


FIGURE 3—MONTHLY VALUES OF TIMES OF TEMPERATURE DISCONTINUITY T_r AND MINIMUM TEMPERATURE T_{min}

——— Monthly variation of T_r.
– – – – Monthly variation of T_{min}.
A — Time of T_{min} for non-thawing snow cover.

sunset both in summer and in winter. On the whole the scatter of the observations about the mean was considerable but times 1½ hours on each side of the mean included about 90 per cent of the observations.

This investigation follows Barthram in accepting that the local sunrise is a good approximation to the time when the minimum temperature occurs, but a special case of T_{min} is shown in Figure 3 — the time of minimum temperature with non-thawing snow cover. A single time suffices, i.e. 0200 GMT.

Values of the constant *C*. Previous investigations have treated the year as a whole, but with the mass of data available in the present investigation it was possible to decide whether better results would be obtained by dividing the year into seasons. It was found that two seasons were sufficient : winter from October to March when the ground was predominantly wet, and summer from April to September when the ground was predominantly dry.

The values of C were found to be reduced by 0·5 degC, during both the winter and the summer seasons, when 8/8 cloud was present from the time of maximum temperature until T_r. Mean values for the stations as a whole are given in Table I, and it was found that these values apply, to most of the stations, within ± 0·2 degC. The difference of 0·5 degC between summer and winter values is consistent with the longer time interval between sunset and the time of T_r in summer.

TABLE I—MEAN VALUES OF THE CONSTANT C

		Summer	Winter
Inversion with base below 900 mb	Radiation nights	3·0	2·5
	8/8 cloud nights	2·5	2·0
No inversion with base below 900 mb	Radiation nights	1·0	0·5
	8/8 cloud nights	0·5	0·0

Dew-points corresponding to only two values of C (appropriate to nil cloud in summer) have been shown on the diagram for the sake of clarity, but values of C appropriate to 8/8 cloud cover may be included by the addition of suitable dew-point scales.

Curves for obtaining T_{min} from T_r with various ranges of gradient wind. Regression equations were calculated for each of the 13 stations, for summer and winter separately, for the two ranges of gradient wind—less than 13 kt and 13–19 kt. This information was then presented to forecasters in a set of gradient wind curves (right-hand side of Figure 2.) The differences between stations were small but statistically significant at the 1 per cent level; they are, however, of limited importance in practice and, therefore, composite curves were constructed which can be recommended with confidence for forecasting night-minimum temperatures in eastern England. The relevant regression equations are :

Summer
Less than 13 kt — $T_{min} = -6{\cdot}1 + 1{\cdot}19\, T_r - 0{\cdot}0141\, T_r^2$
for T_r between 3 and 23°C
(s.d. of T_{min} = 1·61 degC, based on 502 observations).

Summer
13–19 kt — $T_{min} = -3{\cdot}3 + 0{\cdot}82\, T_r + 0{\cdot}0015\, T_r^2$
for T_r between 3 and 23°C
(s.d. of T_{min} = 1·67 degC, based on 311 observations).

Winter
Less than 13 kt — $T_{min} = -5{\cdot}7 + 0{\cdot}92\, T_r - 0{\cdot}0091\, T_r^2$
for T_r between −13 and +16°C
(s.d. of T_{min} = 1·89 degC, based on 362 observations).

Winter
13–19 kt — $T_{min} = -4{\cdot}7 + 0{\cdot}86\, T_r - 0{\cdot}0051\, T_r^2$
for T_r between −8 and +14°C
(s.d. of T_{min} = 1·82 degC, based on 296 observations).

A different technique was applied for the class of gradient winds ≥20 kt. Saunders has suggested that the fall of temperature from T_r to T_{min} is dependent on the gradient wind speed. The temperature fall was accordingly plotted against wind speed, but with large wind speeds the air passing over the station may not be entirely homogeneous and it is not surprising that the scatter of observations was too great for a curve to be drawn.

It was noted that the two curves for winds ≤12 kt and 13–19 kt were similar in shape and there was no reason to suppose that the shape of the curve for higher wind speeds would be different. Consequently, in the absence of any clear relation between gradient wind and temperature fall it has been assumed that the regression equations for 20–30 kt and >30 kt will differ only by a constant value from the equation for 13–19 kt. From a detailed examination of the data the regression equations for the higher wind speeds were assumed to be

Summer	20–30 kt	$T_{min} = -2{\cdot}3 + 0{\cdot}82\, T_r + 0{\cdot}0015\, T_r^2$
	>30 kt	$T_{min} = -1{\cdot}3 + 0{\cdot}82\, T_r + 0{\cdot}0015\, T_r^2$
Winter	20–30 kt	$T_{min} = -4{\cdot}2 + 0{\cdot}86\, T_r - 0.0051\, T_r^2$
	>30 kt	$T_{min} = -3{\cdot}2 + 0{\cdot}86\, T_r - 0{\cdot}0051\, T_r^2$

Relation between average cloud amount and decrease in cooling. The method due to Saunders applied originally to radiation nights; these are the nights when cooling is greatest. On nights of partial or complete cloud cover there will be less cooling, and Summersby[8] published a curve which was intended to give the decrease in cooling which would occur with various amounts of cloud cover. During the early part of the present investigation Summersby's correction for 8/8 cloud was found to be too large and on occasions, without change of air mass, its use gave a forecast night-minimum temperature which was higher than the afternoon maximum temperature. Data for the first two years of the investigation were therefore used to reassess the effect of cloud cover.

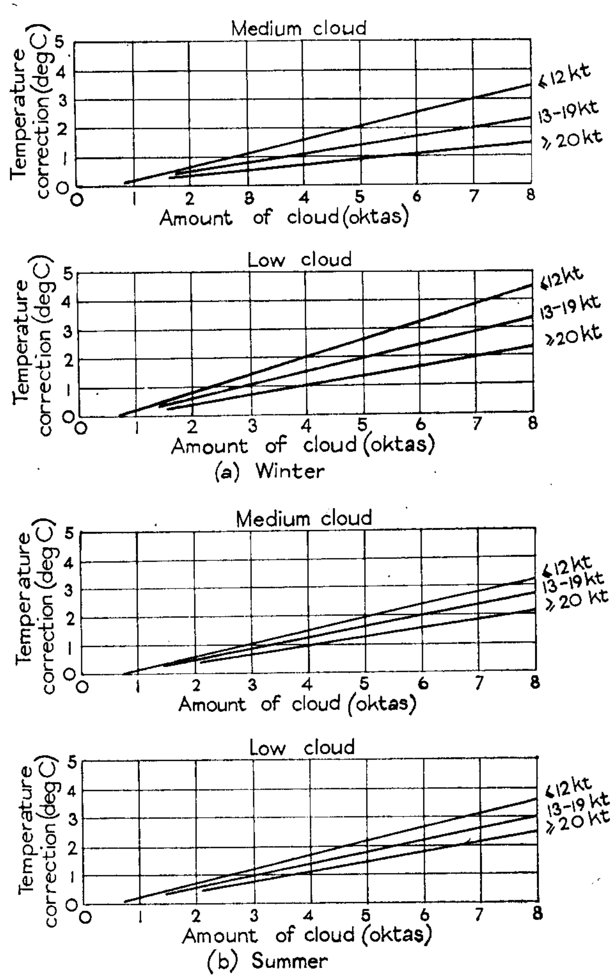


FIGURE 4—GRAPHS SHOWING RELATION BETWEEN AVERAGE CLOUD AMOUNT AND DECREASE IN COOLING

(*a*) Winter (*b*) Summer

The winter and summer seasons were considered separately and each was subdivided into two classes for low and medium cloud. High cloud was disregarded.

The curves of best fit are shown in Figure 4; on the diagrams actually used by forecasters, these curves are conveniently placed in the lower left corner (Diagram (a)) of Figure 2. If both medium and low cloud are expected to be present during the night, only one correction for cloud, whichever is the greater, should be added to T_{min}. The corrected value of T_{min} is then plotted on the diagram.

Further corrections. One further refinement must be mentioned, the correction for reduced length of period of subsequent cooling during the summer, shown graphically in Figure 5, and presented to forecasters in Diagram (*b*) on the bottom right-hand corner of the basic diagram (Figure 2). This correction is applied in addition to the correction for cloud cover mentioned earlier.

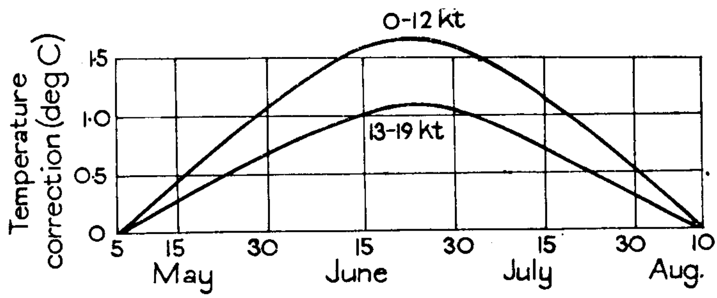


FIGURE 5—CORRECTION FOR REDUCED LENGTH IN SUMMER OF THE PERIOD OF COOLING BETWEEN TIMES OF T_r AND T_{min}

Accuracy attained. The accuracy attained has been discussed by Gordon and Virgo,[9] but it may be pertinent to ask how accurately we can expect to forecast the minimum temperature at a particular spot. It is not necessary to have a thermometer in order to sense variations in temperature within a relatively small area after a clear night with light winds. A 3-kt wind will draw air from 3 miles away in an hour and it is not surprising that the thermogram shows random fluctuations of temperature.

The point will not be discussed further but the standard deviation of T_{min} from the mean varied from 1·6 degC in summer to 1·9 degC in winter and these values may give some indication of the magnitude of the temperature variation in a given area.

Acknowledgements. The authors acknowledge their indebtedness to Saunders and Barthram on whose work the investigation was based. The forecasters and observers who made the observations and laboriously tabulated the data at the various stations are too numerous to mention by name. In addition a great deal of help was given by colleagues at the Meteorological Office, High Wycombe. To all of them the authors extend their grateful thanks.

REFERENCES

1. SAUNDERS, W. E.; Night cooling under clear skies. *Q. Jnl R. met. Soc., London*, **75**, 1949, p. 154.
2. SAUNDERS, W. E.; Some further aspects of night cooling under clear skies. *Q. Jnl R. met. Soc., London*, **78**, 1952, p. 603.
3. SAUNDERS, W. E.; Night cooling under clear skies, Exeter Airport. *Met. Mag., London*, **83**, 1954, p. 9.
4. PARRY, T. H.; Night cooling under clear skies at Shawbury. *Met. Mag., London*, **82**, 1953, p. 368.
5. ROBERTS, E. D.; Night cooling under clear skies at Mildenhall. *Met. Mag., London*, **84**, 1955, p. 48.
6. BRUCE, W. J.; Night cooling curves for Wahn, Germany. *Met. Mag., London*, **84**, 1955, p. 105.
7. BARTHRAM, J. A.; A method of forecasting a radiation night cooling curve. *Met. Mag., London*, **93**, 1964, p. 246.
8. SUMMERSBY, W. D.; Night cooling under cloudy skies. *Met. Mag., London*, **82**, 1953, p. 210.
9. GORDON, J. and VIRGO, S. E.; Comparison of methods of forecasting night minimum temperatures. *Met. Mag., London*, **97**, 1968, p. 161.

551.591.34(427)

CHANGES IN THE VISIBILITY CHARACTERISTICS AT MANCHESTER/RINGWAY AIRPORT

By J. E. ATKINS

Forecasters at Manchester/Ringway Airport consider that the characteristics of visibility there have been changing as a result of smoke control in and around Manchester since about 1960. In this note data are given which, although not derived specifically to test this opinion, do suggest a tendency for poor visibility to be realized less often with light winds during recent years than in previous years.

Tabulations (by punched-card methods) of the visibilities recorded in hourly observations according to the time of year and surface wind were available for Ringway for each of the periods 1949–54, 1955–59 and 1960–64. The following results are based on data for winds of 10 knots or less during the winter half-year (October to March) since these are the conditions when visibility is likely to be seriously affected by smoke.

By itself the change in frequency of poor visibility from one period to another gives an unsatisfactory indication of changing visibility characteristics because the variability in elements which affect visibility has not been taken into account. The variation in windiness from one period to another is particularly likely to affect the frequency of poor visibility — even when the periods taken are as long as five or six years, as is seen from Table I.

TABLE I—PERCENTAGE FREQUENCIES OF LIGHT WINDS AT MANCHESTER/RINGWAY AIRPORT DURING THE WINTER HALF-YEARS OF DIFFERENT PERIODS

Wind speed		Period	
	1949–54	1955–59	1960–64
knots		*per cent*	
Calm	7·5	6·0	11·2
< 4	13·9	13·3	18·8
< 7	28·8	25·5	36·0
< 11	60·3	57·0	62·6

To allow for the effect of varying windiness from one period to another the visibility results are given in the following way in Table II: for each of the light-wind categories during each period the number of observations in the appropriate visibility range is expressed as a percentage of the total number of observations with wind speed as specified. In effect, then, each percentage represents the probability of visibility during the period being in the given range with the wind speed as specified.

TABLE II—POOR VISIBILITY AT MANCHESTER/RINGWAY AIRPORT DURING THE WINTER HALF-YEAR: FREQUENCIES EXPRESSED AS PERCENTAGES OF OBSERVATIONS FOR EACH RANGE OF WIND SPEED

		Range of wind speed *knots*			
		0	1 – 3	4 – 6	7 – 10
(*a*) Period (1949–54)	Number of observations in speed range	1969	1671	3920	8217
	Percentages with visibility less than*: 220 yards	16	8	3	0·4
	440 yards	21	11	4	0·5
	1100 yards	41	26	11	3
	2200 yards	68	52	35	13
(*b*) Period (1955–59)	Number of observations in speed range	1319	1599	2660	6848
	Percentages with visibility less than: 220 yards	20	12	3	0·8
	440 yards	28	16	6	1
	1100 yards	51	32	15	4
	2200 yards	71	54	36	14
(*c*) Period (1960–64)	Number of observations in speed range	2460	1651	3777	5836
	Percentages with visibility less than: 220 yards	14	6	1	0·1
	440 yards	19	8	2	0·3
	1100 yards	38	20	9	2
	2200 yards	61	40	25	8

Note. The tables were compiled from hourly observations, and frequencies are expressed as percentages of the observations in each range of wind speed.

In Table II each percentage for the years 1960–64 is lower than the corresponding percentages for the other periods — particularly 1955–59. It seems, therefore, that a fairly noteworthy change took place about 1960, with light winds becoming less likely to be accompanied by poor visibility than before. It is interesting that this tendency is apparent even for visibilities of less than 440 yards. It might be thought that the frequency of the thicker fogs would be little affected by changes in smoke pollution because these fogs are primarily associated with water droplets. Indeed Wiggett[1] found that at London/Heathrow Airport during a period when smoke pollution was declining the frequency of visibilities less than 440 yards changed little, though there was a considerable decrease in the frequency of visibilities between 440 yards and 1100 yards.

Though the suggestion of changes in the local characteristics is quite strong the evidence is not conclusive. Allowance has been made for varying windiness from one period to another — probably the main meteorological factor causing change in frequency of poor visibility if the intensity of pollution had remained constant — but no allowance has been made for other factors which would

* The metric equivalents are 0·2, 0·4, 1·0 and 2·0 km respectively.

have some significance, e.g. changes from period to period in the way light winds were distributed with respect to wind direction, month, time of day. Advantage has merely been taken of the data which were readily available. It would seem worthwhile to make more searching investigations at Ringway (and other places where significant changes in visibility characteristics were thought to be taking place) taking account, for instance, of wind direction and of the detailed timing of introduction of smoke control in the different areas around.

REFERENCE

1. WIGGETT, P. J.; The year-to-year variation of the frequency of fog at London (Heathrow) Airport. *Met. Mag., London*, **93**, 1964, p. 305.

551.593.653(4)

NOCTILUCENT CLOUDS OVER WESTERN EUROPE DURING 1967.

By J. PATON

Table I contains an account of occurrences of noctilucent clouds (NLC) compiled from reports that were received during 1967 from observers situated mainly in the British Isles; occasional reports were also received from Denmark, Germany, Sweden and pilots in aircraft over the Atlantic. A close network of observers experienced in identifying NLC and keeping nightly watch has now been established over Great Britain and Ireland so it is unlikely that, in favourable observing conditions, a significant number of appearances of NLC between latitudes 50° and 60°N is missed.

In the last four columns are given the maximum elevation above the northern horizon and the limiting azimuths of the cloud field recorded at selected stations at stated times during each display. The geographical latitude and longitude of each station are given to the nearest half degree. When observations permit the determination of the southern boundary of the clouds,[1] this is given in the notes.

When NLC are not observed, no times are entered in the second column. In the case where skies are sufficiently clear at a reasonable number of stations to permit a decision that no NLC are present, this is recorded. 'Cloudy' is entered in the third column when the extent of tropospheric clouds at most stations makes impossible a decision as to whether or not NLC are present.

While the frequency of displays was not significantly different from that of the preceding three years,[1,2,3] the average brightness of the clouds was appreciably less in 1967; there were no really brilliant displays as had occasionally occurred during the past three years. It will be noted that NLC were probably present on every night from 10 June until 12 July, though the majority of the displays were very faint. Though no NLC were reported after 1 August, it is likely that displays were seen in latitudes north of 60°N, since the clouds normally recede northwards in early August. The clouds have been seen in the British Isles on only one occasion (15 August 1966) after early August, and then only close to the northern horizon. It is hoped that when observations are organized under World Meteorological Organization auspices, routine observations will be made at meteorological stations in Scandinavia and Greenland.

TABLE I—DISPLAYS OF NOCTILUCENT CLOUDS OVER WESTERN EUROPE DURING 1967

Date—night of	Times UT	Notes	Station position	Time UT	Max. elev.	Limiting azimuths
31 May –1 June	0005–0100	No details.	56·5°N 7°W	0005	6°	045°
1–2 June		No NLC.				
2–3 June		Cloudy.				
3–4 June	2255	Cloudy over extreme west of Europe but NLC seen from Berlin.	52·5°N 13·5°E	2255	8°	330°–030°
4–5 June		No NLC.				
5–6 June		Cloudy.				
6–7 June	2320–0125	Moderate display of bands, billows and veil.	56·5°N 3°W	2320	12°	350°–030°
				0025	11°	310°–014°
				0102	12°	309°–012°
			55·5°N 3°W	2350	5°	340°–360°
				0045	11°	340°–005°
			55°N 3°W	2355	10°	330°–040°
7–8 June		No NLC.				
8–9 June		Cloudy.				
9–10 June		No NLC.				
10–11 June	0115	Single isolated band seen in latitude 55°N 4·5°W.				
11–12 June	2135–0145	Bright bands and billows. Whirl at eastern end during early phase of display. Southern boundary of display at latitude 58°N over the British Isles and 55°N over Denmark.	57·5°N 3·5°W	2350	41°	320°–030°
				0050	28°	280°–030°
			57·5°N 7·5°W	0005	25°	330°–030°
			56·5°N 7°W	0050	18°	320°–040°
			56°N 3·5°W	2320	15°	360°–020°
			55°N 4·5°W	0001	13°	010°–045°
			55°N 3°W	2345	15°	330°–020°
12–13 June	2245–0215	Extensive display of bands and billows, mostly faint, but brighter later.	57·5°N 7·5°W	0015	30°	320°–020°
			56·5°N 7°W	0100	11°	030°
			56·0°N 4·5°W	2300	20°	290°–040°
			55·5°N 4·5°W	0200	22°	320°–070°
			55°N 3°W	0150	18°	020°–050°
			54·5°N 9·5°E	0100	15°	330°–030°
			53°N 1·5°W	0120	10°	330°–030°
			52·5°N 6·5°W	2252	12°	350°
13–14 June	2342–0150	Faint and isolated clusters of bands.	57·5°N 7°W	0008	30°	340°–020°
			57·5°N 3·5°W	0050	33°	310°–010°
			56·5°N 7°W	0100	21°	340°–030°
			55°N 3°W	0127	9°	300°–010°
			54°N 4·5°W	0150	10°	340°
14–15 June	2215–0145	Very faint veil seen from latitude 55°N.				
15–16 June	0005–0110	Very faint bands.	55·5°N 3°W	0007	11°	340°–020°
			55°N 3°W	0110	15°	340°–010°
16–17 June	2330–0325	Veil and very faint band. Also reported from aircraft over Atlantic.	57·5°N 3·5°W	2330	15°	355°
				0015	20°	340°
			55°N 3°W	0010	5°	340°–010°
			50°N 50°W	0325	5°	355°–005°
17–18 June	0015–0200	Very faint veil and clusters of bands.	53°N 4°W	0020	30°	350°–005°
18–19 June	2325–0200	Very faint bands.	56°N 3·5°W	2350	15°	290°–360°
			55·5°N 4·5°W	0100	10°	330°–010°
19–20 June		Cloudy.				
20–21 June	2300–0225	Extensive display of bright bands and billows reported from Sweden and British Isles. Whirls observed between 0010 and 0050 UT. Extended overhead and into southern sky at Leuchars at 0207 UT. Southern boundary at or south of 55°N.	60°N 17·5°E	2300	50°	315°
			56·5°N 7°W	0015	17°	320°–020°
				0145	40°	320°–090°
			56·5°N 3°W	2318	12°	350°–065°
				0207	125°	150°–265°
			55·5°N 4·5°W	0157	40°	
			55°N 3°W	0200	24°	300°–080°
			54°N 1·5° W	0115	11°	350°–080°
			52·5°N 1°E	0225	25°	340°–030°
21–22 June	0010–0030	Faint bands.	57°N 2°W	0010	38°	280°–030°
22–23 June	2320–0145	Moderately bright display of bands and whirls seen from the British Isles and Denmark	57·5°N 7°W	0055	22°	320°–080°
			57°N 2°W	2355	22°	330°–030°
			56·5°N 3°W	0105	24°	350°–070°
				0145	33°	360°–080°
			55°N 3°W	2320	10°	330°–010°
				0145	16°	350°–030°
23–24 June	2310–0300	Faint bands, observed also from two aircraft flying over Atlantic.	56°N 38°W	0300	15°	
			55°N 3°W	2310	18°	
24–25 June		Cloudy.				
25–26 June	2325–0230	Patches of weak bands. Reported also by aircraft in flight over Atlantic between 51°N 55°W (0130 UT) and 56°N 40°W (0230 UT)	56·5°N 7°W	0050	20°	340°–020°
			54°N 3°W	2325	8°	
26–27 June	2145–0120	Moderately bright bands.	53·5°N 0°	0035	10°	360°
			52·5°N 1°E	0045	4°	360°–045°
27–28 June	0100	Weak bands.	55·5°N 1·5°W	0100	4°	018°
28–29 June	0200	Weak bands seen from aircraft.	53°N 50°W	0200	12°	
29–30 June	0150–0225	Faint bands and billows.	54°N 1°W	0210	90°	

Date— night of	Times UT	Notes	Station position	Time UT	Max. elev.	Limiting azimuths
30 June– 1 July		Cloudy.				
1–2 July	2230–0145	Moderately bright bands seen from 2230 UT from near Copenhagen. Visible over British Isles between latitudes 53° and 58°.	58°N 6·5°W	2350	32°	340°–360°
			57·5°N 7·5°W	2253	39°	320°–010°
			56·5°N 7°W	2245	21°	350°–020°
				0145	19°	320°–030°
			55·5°N 7·5°W	2350	15°	360°
			53·5°N 9°W	0130	3°	012°–022°
			53°N 1·5°W	2347	8°	330°–010°
2–3 July	2340–0150	Bright veil and bands seen between latitudes 52·5° and 57·5°.	57·5°N 7·5°W	0055	20°	338°–030°
			57·5°N 3·5°W	2350	21°	010°–050°
			56·5°N 3°W	2350	21°	010°–050°
			56°N 3·5°W	2350	15°	360°–040°
			55°N 3°W	0031	11°	350°–010°
			54°N 1·5°W	2340	8°	340°–010°
			54°N 1°W	0015	7°	350°–040°
			53°N 1°W	0140	5·5°	
			53° 2·5°W	0145	6°	336°–010°
			52·5°N 6·5°W	0150	4°	360°
3–4 July	2330–0300	Moderately bright bands and whirls seen through low cloud. Bands only observed from aircraft over western Atlantic.	56·5°N 3°W	0020	7°	040°
			56°N 3·5°W	2350	12°	330°–360°
			55°N 3°W	0005	7°	330°–355°
				0105	8°	340°–345°
			54°N 1·5°W	0015	6°	340°–040°
			53·5°N 55°W	0300	10°	
			50°N 65°W	0200	8°	
4–5 July	2130–0130	Weak bands seen from Copenhagen (in zenith at 0100 UT). No reports of NLC from observers in British Isles.				
5–6 July	0400	Report of bands from aircraft over western Atlantic. Cloudy over the British Isles.	52°N 56°W	0400	10°	
6–7 July		Cloudy over western Europe.				
7–8 July		Cloudy.				
8–9 July	2305–0305	Faint bands.	55.5°N 1·5°W	2305	7°	360°–015°
			51·5°N 2°W	0305	20°	260°–280°
9–10 July	2200–2310	NLC—no details.	52·5°N 2°W	2310	10°	315°
10–11 July		No NLC.				
11–12 July	2240–0145	Faint bands.	56°N 10°E	2310	6°	020°
			53°N 4·5°W	0050	8°	360°–005°
12–13 July		No NLC.				
13–14 July		No NLC.				
14–15 July		No NLC.				
15–16 July		Cloudy.				
16–17 July		Cloudy.				
17–18 July		Cloudy.				
18–19 July	0050–0300	Moderately bright bands, observed also from aircraft over the Atlantic.	55°N 3°W	0140	13°	340°–040°
			55·5°N 36°W	0300	20°	
19–20 July		No NLC.				
20–21 July	2200–2400	NLC—no details.	56°N 10°E	2255	6°	340°–020°
21–22 July		No NLC.				
22–23 July		No NLC.				
23–24 July		No NLC.				
24–25 July		No NLC.				
25–26 July		Cloudy.				
26–27 July	2145–2200	Cloudy over British Isles. Weak bands seen from near Essen.	51°N 8°E	2145	12°	335°–350°
27–28 July	0145–0230	Moderately bright display of bands, billows and whirls.	57·5°N 3·5°W	0230	16°	340°–060°
			56·5°N 3°W	0205	7°	025°–065°
28–29 July		No NLC.				
29–30 July		Cloudy.				
30–31 July		Cloudy.				
31 July– 1 August		NLC seen near N. horizon in Jutland.	56°N 10°E	2135	6°	010°

The assistance of the many observers who, by providing visual observations, photographs (see Plates I and II) and sketches, have made this analysis possible, is gratefully acknowledged. These synoptic studies will continue and new observers are invited to send observations to the Balfour Stewart Auroral Laboratory, The University, Drummond Street, Edinburgh 8. Notes on observations appeared in the *Meteorological Magazine*, June 1967, p. 189.

REFERENCES

1. PATON, J.; Noctilucent clouds over western Europe during 1966. *Met. Mag., London*, **96**, 1967, p. 187.
2. PATON, J.; Noctilucent clouds in 1964. *Met. Mag., London*, **94**, 1965, p. 180.
3. PATON, J.; Noctilucent clouds over western Europe during 1965. *Met. Mag., London*, **95**, 1966, p. 174.

Photograph by Dr H. A. Lang

PLATE I—NOCTILUCENT CLOUD OBSERVED FROM NEWTON STEWART, WIGTOWNSHIRE, ON THE NIGHT OF 11–12 JUNE 1967

See page 174

Photograph by Dr H. A. Lang

PLATE II—NOCTILUCENT CLOUD OBSERVED FROM NEWTON STEWART, WIGTOWNSHIRE, ON THE NIGHT OF 20–21 JUNE 1967

See page 174

PLATE III—SNOW ROLLERS AT KINLOSS AIRFIELD, 2 APRIL 1968

Photograph taken looking N. by E. at 1430 GMT shows rollers on the rapidly thawing snow cover. See page 192.

PLATE IV—SNOW ROLLERS AT KINLOSS AIRFIELD, 2 APRIL 1968
Close-up of a snow roller. (The light-meter measures about two inches across.) See page 192.

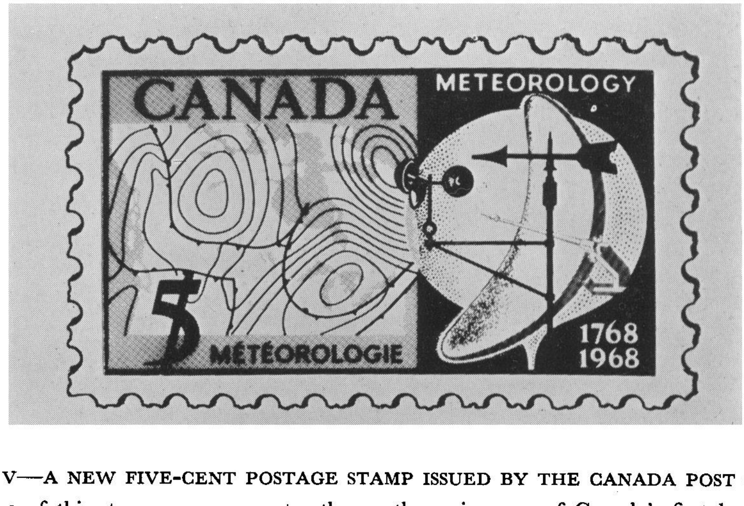


PLATE V—A NEW FIVE-CENT POSTAGE STAMP ISSUED BY THE CANADA POST OFFICE
The issue of this stamp commemorates the 200th anniversary of Canada's first long-term, fixed-point weather observations and is also intended to serve as recognition of World Meteorological Day, 23 March 1968. See page 190.

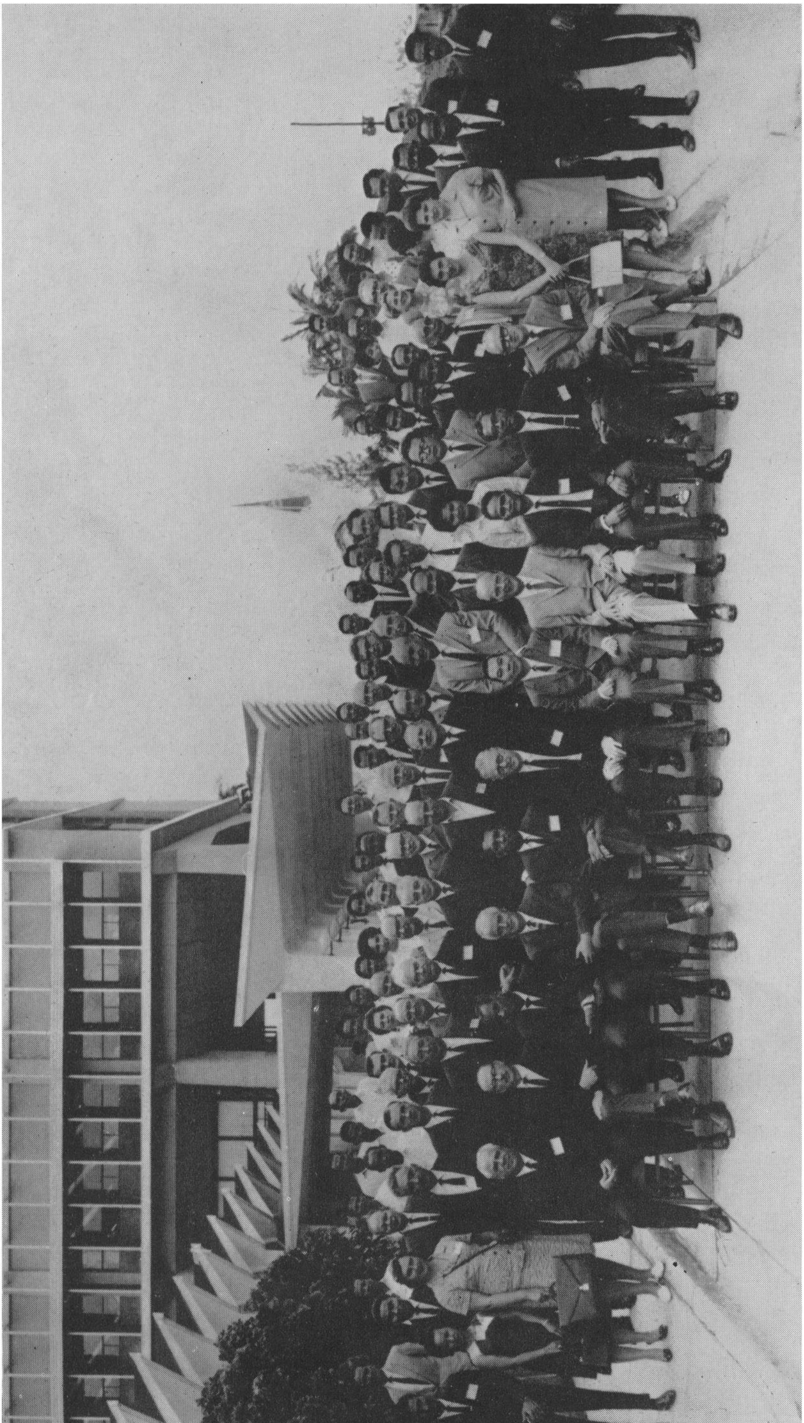


PLATE VI—DELEGATES, REPRESENTATIVES AND OBSERVERS AT THE WORLD METEOROLOGICAL ORGANIZATION COMMISSION FOR AGRICULTURAL METEOROLOGY, FOURTH SESSION, MANILA 1967

Mr. L. P. Smith attended as President of the Commission, and the United Kingdom was represented by Mr. W. H. Hogg and Mr C. V. Smith. See page 187.

551.509.25:551.509.313:629.13

THE ROLE OF NUMERICAL FORECASTS IN THE PROVISION OF METEOROLOGICAL INFORMATION FOR CIVIL AVIATION AT LONDON/HEATHROW AIRPORT

By M. H. FREEMAN, O.B.E., M.Sc.

The main responsibility of the Principal Forecasting Office at London/Heathrow Airport is to produce forecasts for flights by civil aviation aircraft. The volume of traffic makes it quite impracticable to prepare a tailor-made forecast for each flight and, in accordance with ICAO procedures, the forecasting commitment is largely met by the production of sets of forecast charts valid for 0000, 0600, 1200 and 1800 GMT, each covering a wide area. Aircraft captains use the forecast which is closest to the mid-time of the flight. Speeds of movement of systems are marked so that captains can adjust the forecast as necessary.

At present two series of charts are produced: one for long-distance flights across the Altantic on a scale of $1:20\times10^6$ and the other for the much larger number of shorter flights within Europe on a scale of $1:7\frac{1}{2}\times10^6$. For the North Atlantic flights, forecast winds and temperatures are depicted as contours, isotachs and spot temperatures. Flight planners use the contours as streamlines to indicate wind direction and, taking wind speeds by interpolation from the isotachs, draw a series of equal-time fronts at hourly intervals and from these work out the least-time track. Temperatures affect jet engine performance only slightly and are of minor importance. Contour charts are issued for the 700, 500, 300, 250 and 200 mb levels, with the intention that crews should use the chart nearest to their flight level. The 250 and 200 mb charts were introduced during 1967. Prior to that the only source of information above 300 mb was a tropopause/vertical wind-shear chart which showed tropopause height (in millibars) and temperature, the 150 mb temperature, and the vertical wind shear above and below the maximum wind level, which was assumed to be at the tropopause (an obviously rough approximation). Until the end of 1967 it was the practice also to enter information about the positions and speeds of the jet streams. From 1 January 1968 another ICAO alternative has been used showing only maximum wind and tropopause information. It is hoped that aircrews will increasingly use the 250 or 200 mb charts instead of the tropopause chart and that in due course the latter can be discontinued.

Significant-weather charts depict the areas and heights where the pilot may expect to meet such hazards as moderate or severe icing or turbulence, thunderstorms, clear-air turbulence and other less-likely items like duststorms. Many of these phenomena are tied to fronts, and the positions of these and depression and anticyclone centres are marked, together with their expected movements.

For the European flights similar significant-weather charts are produced on a scale of $1:7\frac{1}{2}\times10^6$ on two sheets. The first covers the U.K. and western Europe and is all that is needed for about three-quarters of the departures from Heathrow. For flights to the eastern Mediterranean or towards Moscow an additional sheet is issued, relating to a time three hours later than the first sheet.

Upper wind information for European flights is presented in a different way. Captains have little choice in the route to be flown as they are required to fly along airways, so flight planning to determine a least-time track is not possible (or necessary on these short routes). Forecast winds are, therefore, provided at specified heights at points along the main airways. The big advantage of this form of presentation is that the essential information can be got on to one sheet instead of needing the duplication of contour charts for five or more levels. The aircrews and flight planners find this presentation convenient. For the more distant European flights a Spot Winds II sheet is issued covering the same area as the second significant-weather sheet.

As well as producing forecasts for aircraft leaving Heathrow, the meteorological office is responsible for sending copies of all its forecast charts to other civil aviation stations in the U.K. on the Civil Aviation Meteorological Facsimile (CAMFAX) network. These stations use dyeline machines to copy the Heathrow charts and issue copies to aircrews as documentation for all flights above flight level 50 (5000 feet). The significant-weather presentation is not so suitable for low-flying aircraft; therefore each office, including Heathrow, produces its own forecasts on Forms 2408 or 2405 for these flights.

Since 1 October 1967, Heathrow has taken on a new responsibility, that of Area Forecasting Centre, with the task of providing forecasts for any aircraft leaving Europe west-bound across the Atlantic. The North Atlantic charts are, therefore, also transmitted to Paris, Frankfurt, De Bilt and Copenhagen by landline facsimile and are broadcast by h.f. radio. Frankfurt are re-transmitting Heathrow's charts by l.f. radio facsimile so they are widely available to European meteorological offices who can use them in place of forecasts prepared by themselves. Paris produces forecast charts for flights from Europe to west Africa, Rome produces charts for flights to east Africa, and Frankfurt forecasts to India. These are received at Heathrow and are used for all long-distance flights along these routes.

Heathrow's region of responsibility under the Area Forecasting Scheme prompted the use of $1:20 \times 10^6$ charts, which were introduced experimentally on 1 September 1967. Forecasts were required to cover flights across the North Pole to western America and also flights to the Caribbean. The $1:15 \times 10^6$ charts that had been in use were inadequate for this, whereas the $1:20 \times 10^6$ chart covers the area much better, though it still does not do justice to the southern Caribbean. For the very small number of flights direct from Europe to this area copies of charts forecast by Miami have to be issued.

Before the advent of the Meteorological Office computer, COMET, all the forecast charts were produced at Heathrow by time-honoured subjective methods. Guidance was available from the Central Forecasting Office (CFO) at Bracknell for part of the area but not for America, and the valid times of Heathrow charts were different from CFO's so in practice CFO was not followed in any detail and Heathrow was an entirely independent forecast office. The senior forecaster was the key man. His main task was to produce an 18-hour surface forecast by conventional methods. This was then handed to the significant-weather forecaster who used it as the basis for his forecast, and copies were also made in the form of 1000 mb charts for the two upper-air forecasters, one of whom produced a 500 mb forecast and the other a 300 mb forecast by forecasting a 1000–500 or 1000–300 mb thickness and gridding it with the 1000 mb chart.

Much of the output of COMET's numerical forecasts has been programmed to suit the Heathrow requirement. Contour charts are printed on the line printer in 'contour print' form, the contours being obtained by drawing lines along the edges of the shaded areas. To save the trouble of measuring geostrophic winds COMET also prints each chart in a form giving wind direction, geostrophic wind speed, and temperature at each grid point. The first step in using these charts is to draw isotachs on them by hand. COMET can easily produce separate 'contour print' charts[1] showing isotachs and isotherms, and output in this form is also provided.

On the scale of $1:20 \times 10^6$ COMET produces contour charts for the surface, the 1000–500 mb thickness and the 700, 500, 300, 250 and 200 mb levels, for 18, 24, 30, 36 and 42 hours ahead. In addition, for CFO's use, COMET produces $1:15 \times 10^6$ contour print charts for an area which extends east to Bahrain and these are also received at Heathrow.

Now that COMET material is available, the Heathrow upper-air forecasting technique has changed considerably. Gridding techniques are no longer used and in general COMET contours are accepted and are issued without modification. When necessary, amendments are made to the wind speeds but over much of the chart COMET values are issued. For present-day operations COMET temperatures are satisfactory but for the Concorde some improvement may be needed. The upper-air forecaster still has to produce his own tropopause/maximum wind chart and to do this he has to analyse actual 300 mb and tropopause charts which are plotted at Heathrow. COMET forecasts are derived from a three-level model, using data for 1000, 500 and 200 mb and producing forecast contour heights at these three levels. Forecasts of contour heights at 700, 300 and 250 mb and temperatures at all levels are obtained by regression techniques. Plans are well advanced to improve the regression formulae by introducing 100 mb data, which Woodroffe[2] showed to be advantageous.

Comparisons were made for over a year between the COMET forecasts and forecasts made subjectively at Heathrow, based on the accuracy of equivalent headwinds on three transatlantic routes. At 500 mb the COMET forecasts were clearly superior; at 300 mb the differences were small but the numerical forecasts were slightly better than the subjective forecasts. Under most circumstances a geostrophic wind calculated from a computer chart is a reasonably good approximation to the observed wind. Since the contour lines are not, in general, streamlines, a gradient wind tends to be no better an approximation in practice than a geostrophic wind and the general use of geostrophic winds is justified. Nevertheless, there are some occasions when some form of cyclostrophic correction is desirable; also there is some evidence that computer forecasts underestimate the stronger jet streams; and for these two reasons the Heathrow forecasters make some subjective adjustments to the computed wind speeds to allow for a cyclostrophic component and to take account of later balloon or aircraft winds. No attempt is made, however, to alter the COMET contour patterns.

The temperature forecasts obtained from the computer by regression techniques meet the requirements of present-day jet aircraft quite adequately, but supersonic aircraft will be more temperature-sensitive, especially during the transonic stage between about 300 and 100 mb, so it is essential that better temperature forecasts be produced. COMET does not analyse or forecast temperatures directly, so there is not much hope of reaching the required accuracy with improved regression equations. Another recent short test indicated that COMET's autumn 300 mb temperature forecasts were not too bad, but those for 250 mb and 200 mb were less good. Staff at Heathrow are experimenting with isotherm analysis and simple extrapolation methods and it should not be difficult to improve on COMET in this way, and the required accuracy of a standard error of 3 degC can probably be achieved.

Another difficulty inherent in COMET's regression equation technique is that sometimes insufficient wind shear or temperature lapse is produced between the 300, 250 and 200 mb levels on the charts. Consequently it proves difficult for Heathrow forecasters to produce a realistic and completely coherent set of 300, 250 and 200 mb and tropopause forecasts but an effort has to be made to do this. COMET could produce tropopause height and temperature by regression methods, and this has been requested, but the problem of insufficient shear might still remain. Now that 300, 250 and 200 mb charts are available, the need for a tropopause chart may be open to question and the omission of this chart would simplify the problem of producing mutually compatible charts for the upper troposphere.

In the production of spot wind and temperature forecasts for the European region the Heathrow forecasters could possibly make more use of COMET than they do at present. The methods used are still much as they have been for a long time. The forecaster concerned always has a set of detailed actual upper-wind charts on which to do a 12-hour forecast. His technique is largely to move the troughs and ridges by extrapolation and not alter the speeds much. Nowadays he has COMET's forecast of the trough position to help him but this is an 18- or 24-hour forecast. Another short test did however show that a COMET 18- or 24-hour forecast was almost, if not quite, as good as the extrapolation method. The correct way to deal with this forecast is for COMET to punch a tape with the winds and temperatures interpolated at the spots required, and the information can then be sent to Heathrow by teleprinter and entered on the appropriate form by an assistant. Freezing-level and tropopause height and temperature are also required but regression figures would probably be acceptable on these forecasts for short routes.

No mention has been made so far of the use made of COMET surface charts. Techniques for the production of significant-weather charts at Heathrow are essentially unchanged. The senior forecaster still produces his own surface forcast, and the significant-weather forecaster bases his forecast on it. In many situations, particularly those involving old, slow-moving depressions, the COMET forecast is good, so it is increasingly followed by the forecaster in producing the forecast surface pattern. The senior forecaster still has to forecast the frontal movements and developments, and on occasion he will depart from the COMET isobars, sometimes in a situation with a deepening depression for instance. CFO similarly departs from COMET and due note is taken of CFO's ideas. There are no plans to follow COMET surface forecasts more closely than this at present but when objective forecasts of frontal positions are established the situation might well be reviewed.

A number of reasons why the subjective forecaster still has a part to play in using COMET charts have been indicated. There is another, which rarely occurs but is important when it does, namely, malfunctioning of the computer. On one occasion the forecasts in the vicinity of the British Isles were plausible and had been accepted by CFO, but the forecasts over America seemed improbable to the Heathrow forecasters. It was eventually established that because of a computer fault certain drum transfers had not taken place and the issued forecast was erroneous. It is essential, therefore, that COMET forecasts are carefully scrutinized before they are used.

The subjective forecaster has several important jobs to do if the best use is to be made of COMET forecasts and, although improved computer products may reduce the importance of some of these tasks, for the immediate future we cannot rely on the computer alone.

REFERENCE

1. SAWYER, J. S.; Weather forecasting and its future. *Weather, London*, **22**, 1967, p. 350 (p. 355).
2. WOODROFFE, A.; A regression technique for objective forecasts at 300 mb. *Met. Mag., London*, **95**, 1966 p. 129.

551.577.36(411):519.2

SEQUENCES IN MONTHLY RAINFALL OVER SCOTLAND

By R. MURRAY

In a recent article[1] sequences of months of different rainfall character over England and Wales were examined. This note briefly reports the results of a similar investigation into monthly rainfall sequences over Scotland. In this case 97 years of monthly rainfall data (1869–1965) were classified into terciles R_1, R_2 and R_3. The tercile boundaries used are given in Table I.

TABLE I—TERCILE BOUNDARIES OF SCOTTISH MONTHLY RAINFALL IN INCHES (1869–1965)

Tercile	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
$R_1 \leqslant$	4·5	2·9	2·9	2·5	2·6	2·5	3·5	3·9	3·8	4·5	4·5	4·9
$R_3 \geqslant$	6·1	5·0	4·0	3·6	3·4	3·5	4·5	5·2	5·2	5·9	6·2	6·3

Five types of sequences are examined, namely runs of R_1 (dry), R_2 (average), R_3 (wet), R_1 or R_2 (dry or average) and R_2 or R_3 (average or wet).

For each class of sequence, when account is not taken of the month on which the run begins, no statistically significant difference is found between the observed frequency distribution of the run length and the distribution expected on the basis of chance. This is in agreement with the result found for the England and Wales rainfall.[1]

When the sequences are related to the particular month on which they start, there is in many cases little or no indication that the observed frequency distribution differs from that expected by chance. However, some types of sequences at certain times of the year appear to suggest a reality beyond the play of chance. The runs which may have some predictive usefulness are included in the data contained in Table II.

TABLE II—FREQUENCIES OF RUNS OF AT LEAST 1, 2, 3, ETC., MONTHS OF (*a*) TYPE $R_{1,2}$ (DRY OR AVERAGE) AND (*b*) TYPE $R_{2,3}$ (AVERAGE OR WET) BEGINNING IN SPECIFIED MONTHS

(*a*) $R_{1,2}$

Runs equal to or greater than specified length in months

Starting month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Jan.	22	16	12	8	5	4	3	3	3	3	3	2	2	2	1
Feb.	17	12	7	6	5	4	2	0	0	0	0	0	0	0	0
Mar.	23	15	9	8	6	5	4	4	3	2	0	0	0	0	0
Apr.	26	20	13	7	5	3	3	1	0	0	0	0	0	0	0
May	21	14	8	4	4	3	2	2	2	1	0	0	0	0	0
June	18	12	10	5	5	5	5	2	0	0	0	0	0	0	0
July	22	13	7	5	3	1	1	1	1	1	1	0	0	0	0
Aug.	22	15	11	6	5	3	2	0	0	0	0	0	0	0	0
Sept.	21	13	9	4	2	2	0	0	0	0	0	0	0	0	0
Oct.	15	12	7	6	5	3	2	1	0	0	0	0	0	0	0
Nov.	19	12	8	6	4	2	0	0	0	0	0	0	0	0	0
Dec.	21	15	11	7	4	1	1	1	0	0	0	0	0	0	0

(*b*) $R_{2,3}$

Starting month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Jan.	22	14	7	4	2	1	1	1	1	1	1	1	1	0	0
Feb.	21	14	11	5	3	1	0	0	0	0	0	0	0	0	0
Mar.	24	17	12	8	4	3	2	2	1	0	0	0	0	0	0
Apr.	18	13	10	6	4	3	3	2	2	1	0	0	0	0	0
May	21	13	11	8	6	4	4	2	1	1	1	0	0	0	0
June	20	13	9	6	5	3	0	0	0	0	0	0	0	0	0
July	25	14	7	6	4	2	2	1	1	0	0	0	0	0	0
Aug.	22	17	12	10	5	4	4	1	1	1	1	1	1	0	0
Sept.	22	12	7	4	3	3	2	0	0	0	0	0	0	0	0
Oct.	19	14	12	5	3	2	2	1	1	0	0	0	0	0	0
Nov.	19	13	9	5	3	2	1	0	0	0	0	0	0	0	0
Dec.	23	15	13	11	8	8	4	3	1	1	1	0	0	0	0

Some sequences which indicate persistence in Table II are briefly noted :

(i) $R_{1,2}$ runs from April to May (20/26, i.e. 20 persist in 26 cases).

(ii) $R_{1,2}$ runs from October to November (12/15).

(iii) $R_{1,2}$ runs March/May to June (8/9, i.e. runs starting in March and still in existence in May persist to June in 8 cases out of 9).

(iv) $R_{1,2}$ runs June/July to August (10/12).

(v) $R_{1,2}$ runs of 3 or more months in existence in September tend to persist to October (23/26).

(vi) $R_{2,3}$ runs May/June to July (11/13).

(vii) $R_{2,3}$ runs October/November to December (12/14).

(viii) $R_{2,3}$ runs December/January to February (13/15).

(ix) $R_{2,3}$ runs of two or more months starting in December show a tendency to persist to May.

(x) $R_{2,3}$ runs of 3 or more months in existence in September tend to persist to October (22/26).

The statistical significance of the above-mentioned quasi-persistent features is not certain in many cases, especially when the data are less than about 15. For instance, in case (ix) runs of 2, 3, 4, 5 and 6 or more months are observed on 2, 2, 3, 0 and 8 occasions and these may be compared with chance expectations of 5, 3·4, 2·2, 1·4 and 3 occasions respectively. It is not really justifiable to attempt a chi-square test with such limited data, although there is a suggestion that the difference between the observed and expected frequencies is probably significant at the 5 per cent level. Case (v) may be taken as an example with adequate data, where occasions of no persistence and of persistence to October are observed on 3 and 23 occasions, and these may be compared with chance expectations of 8·7 and 17·3 occasions respectively. On this 2 × 2 contingency table a chi-square test indicates statistical significance at the 5 per cent level.

For small samples, such as case (iii), it is not possible to attempt any statistical test. In judging the reality of quasi-persistent relationships based on such small samples it is evidently only possible to come to the verdict of 'not proven'.

REFERENCE

1. MURRAY, R.; Sequences in monthly rainfall over England and Wales. *Met. Mag., London*, **96**, 1967, p. 129.

551.508.27:533.6.07:681.2.08

AN INVESTIGATION INTO THE RESPONSE OF THERMOMETER SCREENS — THE EFFECT OF WIND SPEED ON THE LAG TIME

By D. BRYANT

Introduction. The lag of different thermometers has been the subject of many papers in the past. The *Handbook of meteorological instruments*[1] also contains detailed information concerning the determination of the true temperature of the medium in which a thermometer may be placed at any time. The present paper sets out to investigate the lag of a thermometer when placed inside a screen, a problem which seems to have received little attention in the past.

Field experiments. Of the reports published, that of K. Langlo[2] is believed to be the only one containing a quantitative result. During the solar eclipse of July 1945 he used the temperature and wind speed readings of some 67 stations throughout Norway to obtain a relationship between the lag time of the Norwegian screen used and the wind speed.

He obtained a scatter of results and found that $L \simeq 24/(v)^{\frac{1}{2}}$ where L is the lag time in minutes and v is the wind speed in metres per second (m/s). Although approximations were made for changes in weather over Norway, the experiment was not altogether satisfactory because of uncontrollable factors such as radiation and wind speed.

A comparative assessment of various screens was made by L. B. MacHattie[3] (Department of Forestry, Ottawa, Canada) in the summer of 1963. Although the experiment did not set out to find the lag times of the screens, certain information on the response times can be obtained from the readings. The lag time of the Stevenson screen in the evening amounts to 10 minutes with respect to the sandwich screen used. The sandwich screen consisted of 4 horizontal aluminium plates mounted in a vertical stack. Each plate was separated from adjacent plates by 4 thermally insulated pillars 2–3 cm long. The thermometer was placed between the 2 inner plates. Presumably the sandwich screen itself has a lag (which could not be determined because it had the quicker response) so that, at the wind speed recorded (approximately 0·7 m/s), the Stevenson screen may well have an actual lag time of 20 minutes. This is in spite of the fact that, in order to read the thermometer, the Stevenson screen had to be opened 3 times every 15 minutes, thus decreasing the measured lag time.

Controlled experiment. It is obvious that controlled conditions are necessary for an accurate determination of the lag times of screens. This was made possible by using the wind-tunnel facilities at Bracknell.[4] It is appreciated that in a small wind-tunnel (working section approximately 2 × 1 × 1·25 metres) the screen must have a considerable effect on the airflow, so that there is some doubt about the uniformity of airflow and the accuracy of the measured air speeds. These uncertainties are, however, far less than they would be in a field experiment.

Two screens were investigated, a Stevenson screen, and an electrical resistance thermometer screen. The latter is a small, single louvered, screen with internal dimensions approximately 38 cm × 10 cm × 6 cm. The screens were set up, in turn, in the working section of the wind-tunnel as shown in Figure 1. The screen under investigation was placed over a heater, which was used to heat the screen to a convenient temperature above the air temperature in the wind-tunnel. The screen was surrounded with expanded polystyrene to ensure that the air in the wind-tunnel was heated as little as possible.

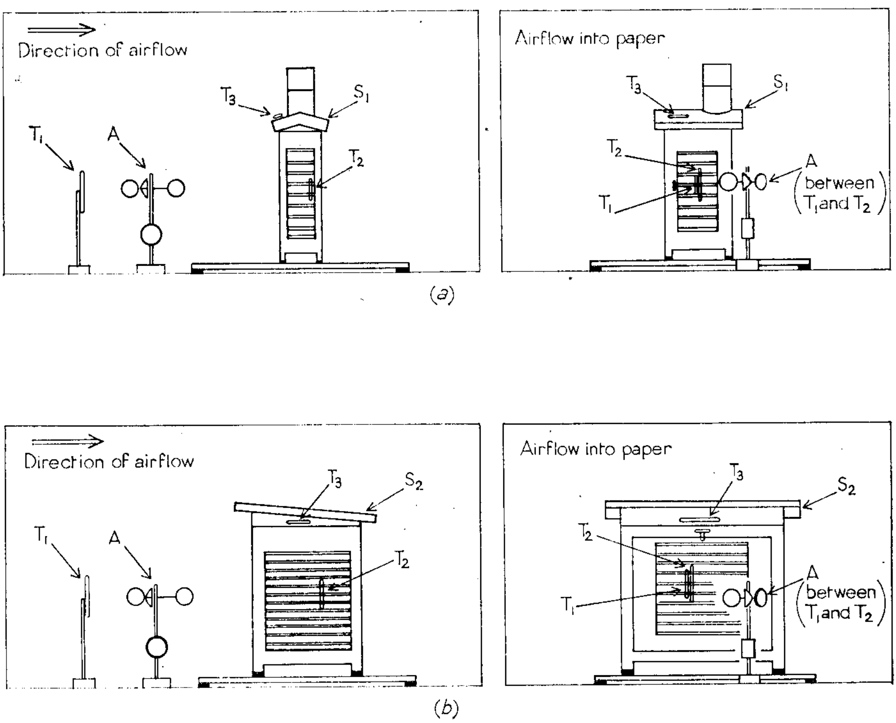


FIGURE 1—POSITIONS OF THERMOMETERS, ANEMOMETER AND SCREENS RELATIVE TO THE AIRFLOW INSIDE THE WIND-TUNNEL

(*a*) (*upper diagram*) Resistance thermometer screen.

(*b*) (*lower diagram*) Stevenson screen.

T_1, T_2 and T_3 are electrical resistance thermometers (T_1 upwind of screen, T_2 within the screen and T_3 outside the screen).

S_1 Resistance thermometer screen, S_2 Stevenson screen.

A Sensitive cup anemometer.

Three electrical resistance thermometers were used. Thermometer T_1 was positioned upwind of the screen to measure the ambient temperature of the air in the wind-tunnel. Thermometers T_2 and T_3 were positioned with T_2 inside and T_3 outside the screen, as in Figure 1, and were wired to an electrical resistance bridge to measure the temperature above ambient (i.e. temperature above the upwind thermometer reading). The heater was then switched on and the screen was left to warm up.

It was assumed that the screen was uniformly heated when thermometers T_2 and T_3 were at approximately the same temperature (within 1 degC). When this state was reached, the expanded-polystyrene sheets were removed, the heater was switched off and the wind-tunnel started. Wind speeds below 5 m/s were set only approximately, using a light-wind meter; to set speeds above 5 m/s a predetermined mark on the control dial was used. Care was taken not to over-ventilate the screen when starting. The wind speed was then accurately measured using a sensitive cup anemometer (positioned between thermometer T_1 and the screen, as in Figure 1).

Readings of temperature against time, t, for the screen were then taken at this wind speed and repeated for about 10 other wind speeds. The whole procedure was repeated for the resistance thermometer screen.

If Newton's law of cooling is assumed we can write

$$dT/dt = -(1/L)\,(T - T_A),$$

where T is the temperature in the screen in degrees Celsuis, T_A is the ambient temperature in degrees Celsius and L is the time constant of the screen (lag time in minutes), giving an integration,

$$\log_{10}(T - T_A) + \text{constant} = -t/L.$$

Results and discussion. On plotting $\log_{10}(T - T_A)$ against time for the different wind speeds, straight-line graphs were obtained. However, there was a tendency in the first 90 seconds for the rate of cooling to be greater

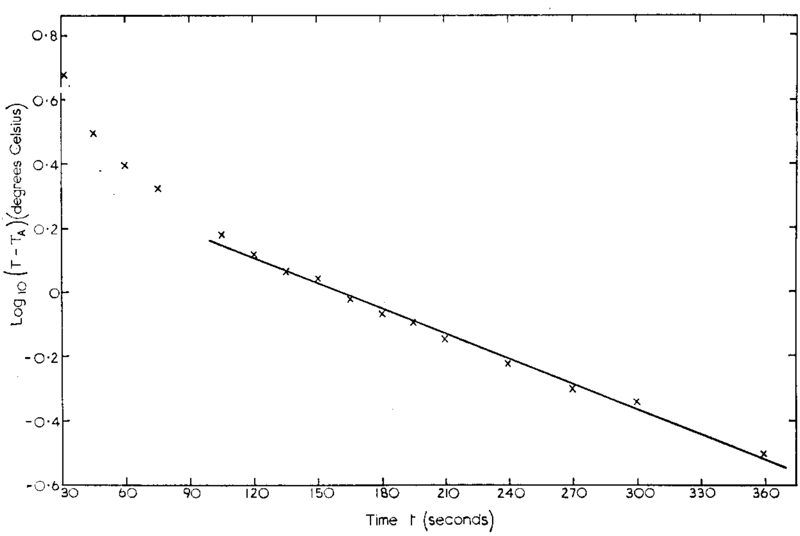


FIGURE 2—GRAPH SHOWING RATE OF COOLING OF THERMOMETER T_2 IN THE RESISTANCE THERMOMETER SCREEN FOR A WIND SPEED OF 8·5 M/S.

than that expected (see Figure 2). This was more obvious in the instance of the resistance thermometer screen. The rate of cooling during the first 90 seconds did not seem to be affected in any systematic way by the wind speed but the 'main' straight line had a gradient which increased with wind speed. This line was used to ascertain the lag time (gradient of line $= -1/L$), the initial readings being ignored.

It was found that for both screens the lag time decreased with wind speed. A graph of $\log_{10}L$ against $\log_{10}v$ was then plotted for each screen (Figure 3). For the Stevenson screen it was found that

$$1/L \simeq 19/(v)^{\frac{1}{2}}$$

where L is the lag time in minutes and v is the wind speed in metres per second, and for the resistance thermometer screen

$$1/L \simeq 12/(v)^{\frac{1}{3}}.$$

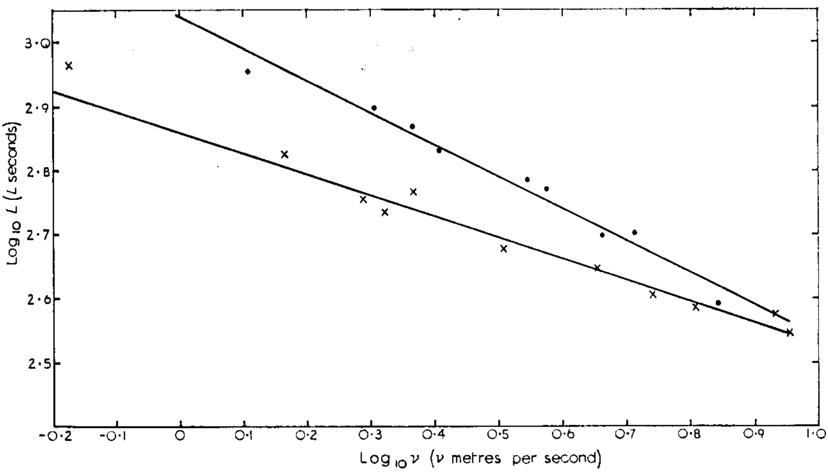


FIGURE 3—THE EFFECT OF WIND SPEED ON THE LAG TIME OF A THERMOMETER SCREEN

. Stevenson screen. x Resistance thermometer screen.

The results show that for the Stevenson screen for wind speeds from 0 to 7 m/s the lag time decreases from approximately 30 to 6·5 minutes. For the resistance thermometer screen for wind speeds from 0·7 to 9 m/s the lag time decreases from 15·3 to 6 minutes. The *Handbook of meteorological instruments* gives the response time of a mercury-in-glass thermometer as 56 seconds at 15 ft/s (4·6 m/s). It is, therefore, apparent that the response of the screen is the dominating factor in any determination of the lag of a thermometer in a screen.

REFERENCES

1. London, Meteorological Office. Handbook of meteorological instruments, Part 1. London, HMSO, 1956.
2. LANGLO, K.; The effects of the solar eclipse of July 1945 on the air temperature and an examination of the lag of a thermometer exposed in a screen. *Met. Annr, Oslo*, **3**, 1949, p. 59.
3. MACHATTIE, L. B.; Radiation screens for air temperature measurement. *Ecology, Durham, North Carolina*, **46**, 1965, p. 533.
4. HARTLEY, G. E. W.; Wind-tunnels in the Meteorological Office. *Met. Mag., London*, **95**, 1966, p. 144.

551.5:061.3:63

WORLD METEOROLOGICAL ORGANIZATION COMMISSION FOR AGRICULTURAL METEOROLOGY, FOURTH SESSION, MANILA, 1967

By C. V. SMITH

Introduction. The meeting was held in Manila, between 15 and 29 November 1967, at the invitation of the Philippine Government. Mr L. P. Smith attended as President of the Commission, and the United Kingdom was represented by Mr W. H. Hogg and Mr C. V. Smith.

The Commission meets at approximately four-year intervals and its Sessions are the time at which broad guide lines are laid down on projects and problems of international concern in agricultural meteorology. It follows that representatives of other international organizations with whom the World Meteorological Organization (WMO) has worked closely in the past — organizations such as the Food and Agricultural Organization (FAO), United Nations Educational Scientific and Cultural Organization (UNESCO), and the United Nations Development Programme — were present as observers, in addition to the national delegates from some 28 member countries of WMO (see Plate VI).

The Fifth World Meteorological Congress has recently been reported on by Harley.* The Commission for Agricultural Meteorology (CAgM) is one of the bodies which carries out the work of WMO. Commitments are incurred through the deliberations of the Commission; these need not necessarily be reflected in the adoption of specific programmes of work or observations by national meteorological services. In the present case, the involvement is largely one of individual meteorologists in specialist investigations.

The Working Groups. In the long interval between its full Sessions, the CAgM is far from moribund. Aside from the multifarious co-ordinating and scientific activities of its President, life is breathed into the Commission by its Working Groups.

These Working Groups are international in character and normally, but not necessarily, will consist of nominated or invited experts from national meteorological services. In the main it is the Working Groups who carry out the detailed scientific work of the Commission and who report, review and comment on investigations and developments in particular areas of agricultural meteorology. Naturally enough, at Manila a considerable time was spent in discussing the reports submitted by current Working Groups and in studying proposals and devising terms of reference for future Working Groups.

It was gratifying that the reports of the Working Groups with which Meteorological Office staff were associated were recommended for publication as *WMO Technical Notes*. These reports were on the epidemiology of wheat rusts, on the storage of cereals and on observations in animal experiments. In addition a report, from the U.K. Meteorological Office, on the codling moth was noted with appreciation.

---

* HARLEY, D. G.; Fifth World Meteorological Congress. *Met. Mag., London*, **96**, 1967, p. 282.

Altogether, there were reports from or on behalf of 12 Working Groups, whose additional interests ranged from crop production to crop pests and crop damage by air pollutants, and to the problems raised by land form and soil moisture.

In the interval between the third and fourth Sessions, the President had exercised his prerogative of publishing the report of the Working Group on Syllabi for Instruction in Agricultural Meteorology and of establishing additional Working Groups to assist with locust control and with agro-meteorological aspects of micrometeorology. Considerable work and development in micrometeorology takes place outside of national meteorological services. The initiative of the President, in bringing together a Working Group of 'unaffiliated' micrometeorologists — each of international repute — into the ambit of the Commission, was warmly supported.

In addition to the more specialist work, CAgM is at pains to keep its house in order. To this end, the Session at Manila saw the updating of the *Guide to Agricultural Meteorological Practices* and the relevant sections of the *WMO Technical Regulations*. Amendments were suggested to the chapters dealing with the methods of calculating evaporation and evapotranspiration, with forest meteorology and with the measurement of soil temperature.

The problems of information and literature retrieval are not peculiar to agricultural meteorology. In an effort to encompass the increasing flow of literature, the list of periodicals to be shown in the *Guide* was expanded and the Commission took the further step of recommending that the national progress reports should be supplemented by annual national bibliographies in agricultural meteorology. The suggestion was also made that national progress reports should contain sufficient details of projects in hand (or completed) for the institutes or individuals concerned to be identified.

Agrometeorological observations. As in other branches of meteorology, the agricultural meteorologist has a requirement for certain specialized observations for day-to-day operational work and advice. The procedures and instruments used need to be standardized between countries, as far as this is practicable. Reports were presented to the Commission on the progress made with the measurement of leaf wetness, the measurement of soil temperature and with the measurement of minimum temperatures at, or close to, the ground. Whilst minimum temperature measurements made over grass as a standard surface have a relevance to agricultural events in this country, this is far from being true in many countries. The Commission briefly considered the advisability of introducing an international standard surface for this kind of measurement (perhaps a concrete slab), but decided against it.

The use of aerial surveys to determine the state of crops is not new. In this country for example, infra-red photographs have been used to determine the extent and spread of potato blight infections. The Russian delegation reported on the development of an airborne photometer for the survey of crops over wide areas.

Certain delegates were concerned with hail as an agricultural hazard and the requirement for a 'recording hail gauge' was passed to the Commission dealing with instruments and methods of observation (CIMO).

The collection of biological and meteorological data should proceed side by side. Phenological observations were discussed, though international standardization was not necessarily recommended. The development of typical farming calendars was suggested.

Agrometeorological training : Symposia and collaboration. Such a paragraph heading may seem a little disjointed. Yet the agricultural meteorologist in this country is largely self-taught. He probably moves into agricultural meteorology after many years of synoptic work and though his development could not be said to proceed entirely in isolation, since his contacts may now be largely with agriculturists, much depends on the meteorological implications he personally reads into problems put to him. A broad basic education is implied and specific further education could perhaps be said to be obtained through informal discussion at scientific meetings.

Though this system may work well enough here, it is natural for other countries, especially those where a national agrometeorological service may be in its infancy, to feel the need for a more formal training. Delegates from Iran and Ethiopia left no doubt about this matter. The efforts of the Working Group concerned, to indicate the subject matter for schemes of study, have already been mentioned.

But personal contact and discussion with co-workers should be welcome at any level of expertise. The Commission at Manila examined an assessment of the WMO Regional Seminar in agrometeorological problems in Africa (Cairo 1964) and looked forward to the report from the Melbourne Seminar (1966). For the same reasons, the Commission welcomed the UNESCO-sponsored Symposia on Ecosystems (Copenhagen 1965) and on Methods in Agroclimatology (Reading 1966).

At this Reading meeting, details were made known of the FAO/UNESCO/WMO joint agroclimatic studies of the semi-arid zones of the Middle East and of the lands south of the Sahara. The Commission expressed the hope that this kind of collaboration would be continued and suggested an inter-agency survey of the humid areas of Region V (South-west Pacific).

The International Biological Programme (IBP) is now under way. Individual agricultural meteorologists are obviously involved, but Mr L. P. Smith reported to CAgM that collaboration had been offered by the President of the International Society of Biometeorology.

Perhaps one of the most ambitious areas of international collaboration in meteorology is the projected World Weather Watch (WWW)—it is also probably one of the more expensive projects. The delegation and individuals who might be said to have a personal stake in the WWW project were readily identified. The Commission as a whole gave a formal acceptance to this enterprise and took time to consider what benefits might accrue to agricultural meteorology. It was agreed that basic data and forecast requirements should be further studied nationally, but that the requirements set out in *WMO Planning Report No. 22* represented an admirable synopsis. The Commission in Manila endorsed this planning report by its President and asked the Advisory Working Group which supports the President to maintain a continuous review of the way in which WWW might serve agricultural meteorology.

Future work. Eight Working Groups were set up to carry on the work of the Commission until its Fifth Session. (A provisional invitation has been extended by the Government of Iran for this to be held in Teheran.) The President's Advisory Group has already been mentioned, as have the Groups on locusts and micrometeorology. The existing Group on the production of lucerne was reconstituted. New Working Groups were appointed to look into the methods to be used for agroclimatic surveys and for the assessment of drought. Other Groups are to look at an important disease of rice and into weather as a determinant of the quantity and quality of crop yields.

Individual rapporteurs were nominated on nine topics. The climate under glass is to be given attention. There will be studies of at least two insect pests. Work is to continue on pollution and diffusion studies and on meso-climates. Our own agricultural section is to report on three subjects through the preparation of international bibliographies and preferably by the preparation of review articles as well. These subjects are minimum temperatures near the ground, the epidemiology of the Colorado Potato Beetle and environments for housed animals. But perhaps the greatest demands, both officially and privately, will continue to fall upon Mr L. P. Smith. In an impressive vote of confidence, the Commission unanimously re-elected him as President for a second term of office. Dr V. V. Sinelshikov (U.S.S.R.) was elected Vice-President.

Envoy. In looking back on the Fourth Session of the Commission for Agricultural Meteorology it is important to emphasize the efficient services provided to the Conference by the Philippine Weather Bureau and a pleasure to record the hospitality and welcome provided both by the Philippine Government and by private individuals. Through their good offices, off-duty tours were arranged and up-country visits made to the Rice Research Institute and to a sugar plantation. It was impossible not to acquire memories of a pleasant country and a charming people.

NOTES AND NEWS

551.506.2(712 7)

An Eighteenth Century series of observations from Fort Prince of Wales, Canada

By courtesy of Meteorological Branch, Department of Transport, Canada.

A five-cent stamp issued by the Canada Post Office on 13 March 1968 commemorates the 200th anniversary of Canada's first long-term, fixed-point weather observations (see Plate V). The Canadian Weather Service (now Meteorological Branch) dates its founding from the year 1839.

The weather readings commemorated by this stamp were started at Fort Prince of Wales, Churchill, by William Wales and Joseph Dymond on 10 September 1768; observations several times daily by barometer and thermometer continued until 27 August 1769. Earlier remarks on the weather have been recorded by soldiers, explorers and others, but these are largely non-instrumental and were made in transit rather than at a fixed point.

Dymond and Wales were at Hudson Bay under instructions from the Royal Society to observe the transit of Venus. Wales, one of the foremost astronomers and mathematicians of his day, was later to accompany Captain Cook on voyages round the world.

The observations made at Fort Prince of Wales were published in the *Philosophical Transactions* of the Royal Society in 1771 (Vol. LX for the year 1770). The article is lengthily entitled 'Journal of a Voyage Made by Order of the Royal Society, to Churchill River, on the North-west Coast of Hudson Bay; of thirteen Months Residence in that Country; and of the Voyage back to England; in the Years 1768 and 1769; by William Wales'. Attached to the article are the meteorological tables, 42 pages in length, entitled 'Observations on the State of the Air, Winds, Weather, etc., Prince of Wales's Fort on the North-West Coast of Hudsons Bay in the years 1768 and 1769, by Joseph Dymond and William Wales'.

The first weather entry is dated 10 September 1768 ('rainy, with a gentle breeze') and the final one 27 August 1769 ('took down the instruments, and packed them up'). Observations were made under the headings of: barometer, thermometer (one inside, one outside), winds, weather, etc. Observations were taken three times a day on the average but there are some days with two, some with three, and the occasional day with as many as five observations. Most of the observations entered in the journal are straightforward except that the terminology is more colourful than is used today. For example, 'A very keen frost air', 'the wind high, and much frozen sleet', 'the air extremely sharp'.

Occasionally the comments range a little further afield: 'the liquid in which the plumb-line of the quadrant is immersed, consisting of water and about one fourth part brandy, is this morning froze so hard that I can scarcely make an impression on it with my finger'; and this comment on the passage of a cold front (unknown as such, of course, in those days): 'Snowing; at this very time, the wind sprung up at northwest on which there was instantly a very sensible change in the heat of the air, so as to be much colder. It had been almost calm all this morning; but about 11 a.m. there arose, almost instantaneously, a perfect hurricane in the northwest quarter, which brought along with it a prodigious quantity of snow, and also a very remarkable change in the temperature of the air'.

It should be noted that these first meteorological observations were taken at Fort Prince of Wales, which lies some 4 miles to the south of Fort Churchill, Manitoba, where weather reports were later taken. In recent years the official observing site has been at the airport, located some 10 miles from Fort Churchill.

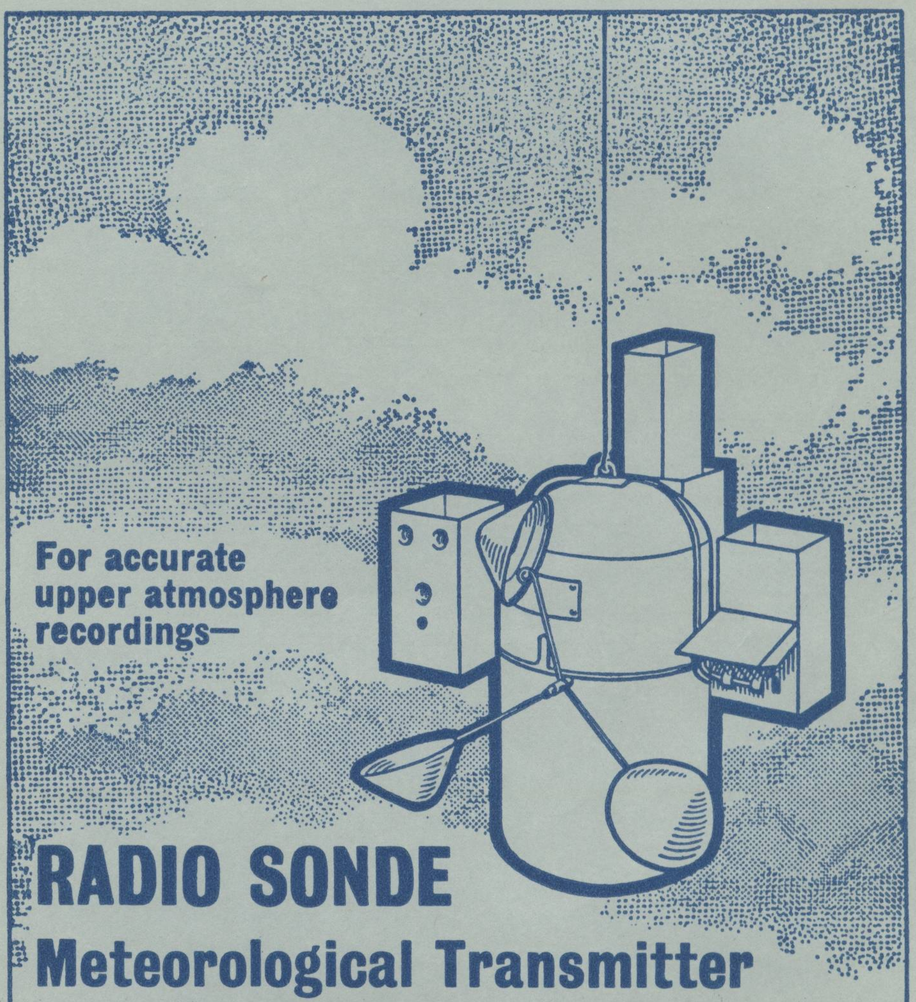
The new postage stamp is also intended to serve as Canada's recognition of World Meteorological Day, 23 March 1968, which is devoted to the theme of 'Weather and Agriculture' this year.

Snow rollers* at Kinloss airfield, 2 April 1968

The unusual snow formation shown in Plates III and IV occurred at Kinloss airfield, Moray, after the passage of a trough of low pressure from the north, at 1235 GMT. Snow had been falling for three hours beforehand in an air temperature of about −3°C and a depth of 3 cm had accumulated. At the trough the wind veered from SW to light NNE, directly off the Moray Firth, and the air temperature rose sharply to above freezing-point. At 1255 GMT the wind speed rose rapidly to a mean of 30 kt.

A. N. TUCKER

* Snow rollers: cylinders of snow formed and rolled along by the wind.


For accurate upper atmosphere recordings—
RADIO SONDE
Meteorological Transmitter
The WB Radio Sonde is essential for high altitude weather recording (up to 66,000ft.), and is available with parachute, radar reflector and battery, or as a single unit, complete with met. elements.
For full specification of the WB Radio Sonde—which is used by the U.K. Meteorological Office, and many overseas Governments—please write or telephone
WHITELEY
ELECTRICAL RADIO CO. LTD.
MANSFIELD
NOTTS
ENGLAND
Tel: Mansfield 24762
WB187

THE METEOROLOGICAL MAGAZINE

VOL. 97 NO. 1151 JUNE 1968

CONTENTS

Page

Comparison of methods of forecasting night-minimum temperatures. J. Gordon and S. E. Virgo 161

Results of an investigation into forecasting night-minimum screen temperatures. E. B. Tinney and P. Menmuir ... 165

Changes in the visibility characteristics at Manchester/Ringway Airport. J. E. Atkins 172

Noctilucent clouds over western Europe during 1967. J. Paton 174

The role of numerical forecasts in the provision of meteorological information for civil aviation at London/Heathrow Airport. M. H. Freeman 177

Sequences in monthly rainfall over Scotland. R. Murray ... 181

An investigation into the response of thermometer screens — the effect of wind speed on the lag time. D. Bryant 183

World Meteorological Organization Commission for Agricultural Meteorology Fourth Session, Manila, 1967. C. V. Smith... 187

Notes and news

An eighteenth-century series of observations from Fort Prince of Wales, Canada... 190

Snow rollers at Kinloss airfield, 2 April 1968 192

NOTICES

It is requested that all books for review and communications for the Editor be addressed to the Director-General Meteorological Office, London Road, Bracknell, Berkshire, and marked "for Meteorological Magazine."

The responsibility for facts and opinions expressed in the signed articles and letters published in this magazine rests with their respective authors.

All inquiries relating to the insertion of advertisements in the Meteorological Magazine should be addressed to the Director of Publications, H.M. Stationery Office, Atlantic House, Holborn Viaduct, London E.C.1. (Telephone: CITy 9876, extn 6098).

The Government accepts no responsibility for any of the statements in the advertisements appearing in this publication, and the inclusion of any particular advertisement is no guarantee that the goods advertised therein have received official approval.

Printed in England by The Bourne Press, Bournemouth, Hants.
and published by
HER MAJESTY'S STATIONERY OFFICE

3s. 6d. monthly **Annual subscription £2 7s. including postage**

Dd. 133110 K16 6/68 S.O. Code No. 40-43-68-6