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Retirement of Dr N. E. Rider

Dr Norman Rider, Deputy Director (Observational Services), retired from the Meteorological Office on 8 January 1982 after a career of almost 35 years in the Office during which time he carried out a wide variety of jobs on both the Services and Research sides of the Office.

Dr Rider studied for his first degree at University College, Exeter (as it was then) and graduated with high honours in Special Physics in 1943. He spent the remaining war years in the Royal Navy and was demobilized in 1947 when he joined the Office as a Scientific Officer. His initial posting was to the Instrument Branch, then at Harrow, where his main job was concerned with equipping the four original Ocean Weather Ships.

Towards the end of 1947 Dr Rider was posted to Kew Observatory where, under the guidance of Dr G. D. Robinson, he worked on radiation and boundary-layer problems. His research was concerned with turbulent exchange processes near the surface and this led to a posting in late 1949 to the School of Agriculture at Cambridge. Here he carried out many experiments relating to evaporation from various crop surfaces and published several important scientific papers on this subject. In 1958 he was awarded a three-year fellowship by the Australian Commonwealth Scientific and Industrial Research Organization. Whilst in Australia he continued his boundary-layer studies, extending them to consider the effect of advection on boundary-layer exchange processes. The excellence of this research led to him being awarded a London University D.Sc. in 1962.

Dr Rider was posted to the Instrument Development Branch of the Office on his return from Australia in 1961. He was promoted to Senior Principal Scientific Officer in 1967 when he became the Assistant Director in charge of that Branch until 1970. He then was detached to Geneva where he became a consultant to the Secretary-General of WMO for two years. Whilst in Geneva he undertook, with others, the planning of the GARP Atlantic Tropical Experiment (GATE). This was subsequently one of the most successful international meteorological field experiments that have taken place, and this was in no small way due to the expertise of the planning staff.

When Dr Rider returned to the Office in 1972 he became Assistant Director in charge of the High Atmosphere Branch. During the four years that he held that post he was especially involved in the planning of special observing systems for the tropics exploiting geostationary satellites. In 1976 he was promoted to Deputy Chief Scientific Officer and became the Deputy Director responsible for observational services and climatology until his retirement in January 1982.

During his long career in the Office Dr Rider acquired both an expertise in experimental meteorology and in organizational matters. His sound common-sense approach to problems was of great value, both nationally and internationally. Within the Office he was a valued member of the Directorate and for the last three years an exceptionally loyal and efficient deputy to the Director of Services. He has been a member of the North Atlantic Ocean Station (NAOS) Board for several years and was Vice-President for the last three years. Indeed, it is a remarkable coincidence that Dr Rider's first job within the Office was to equip our first four weather ships and almost his last was to visit the OWS *Admiral FitzRoy* as she was preparing to sail on the last voyage made by one of our own weather ships.

We wish him and Mrs Rider a very long and happy retirement.

F. H. Bushby

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Forecasting daily maximum surface temperature from 1000–850 millibar thickness lines and cloud cover

By N. S. Callen and P. Prescott

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Summary

A regression equation to predict daily maximum surface temperature throughout the year is developed in terms of the expected 1000–850 millibar thickness. The model has a simple form and allows for variable cloud cover and seasonal effects. In addition an interaction component is included which adjusts for different effects of cloud cover at different times of the year. Three years of daily weather records at Crawley and Gatwick Airport are used to estimate the parameters in the model and an additional year of data is used to assess the model's performance.

1. Introduction

Forecasting surface temperature accurately for up to 24 hours ahead, and approximately for a further two or three days, is evidently important for many types of industry, particularly the gas and electricity industries as discussed by Parrey (1972). Several methods of predicting maximum or minimum surface temperatures are available. Gold's (1933) method for maximum temperature uses the depth of the layer which is changed from an isothermal to a dry adiabatic by solar heating on clear days. Johnston (1958) modified this method and it was discussed further by Inglis (1970). Boyden (1958) described a procedure to predict daily mean surface temperature from the 1000–500 millibar (mb) thickness lines and, later, Boyden (1962) extended these ideas to the prediction of maximum temperatures. Inglis (1970) discussed methods based on the tephigram and compared forecasts of maximum temperature using these methods with forecasts based on the 1000–850 mb thickness. He concluded by saying that the direct, and possibly the best, way to establish a relationship between thickness and maximum temperature would be by means of a regression equation, possibly determined separately for each month except that the midsummer months could be grouped together.

Forecasts of minimum temperatures may be obtained using McKenzie's (1944) method or from a regression equation applicable to the whole year developed by Craddock and Pritchard (1951). Tinney and Menmuir (1968) discussed the results of forecasting in two separate seasons defined as summer, April to September, and winter, October to March. Regression models for these two seasons were compared with the yearly regression equation of Craddock and Pritchard and with McKenzie's method by Gordon, Perry and Virgo (1969). It was clear from their comparisons that the results for the different methods are similar, 'provided sufficient trouble is taken to establish a reliable basis', for the tabulations and equations involved.

Here we consider the relationship between the daily maximum temperature and the 1000–850 mb thickness, using regression analysis to build a model including adjustments due to the extent of cloud cover and seasonal effects. The objective is a simple equation, applicable to the whole year, based on easily obtained variables which may be used to provide accurate forecasts for one or more days ahead.

2. Variables used in the analysis

In order to predict the surface maximum temperature from other easily assessed meteorological variables, it is necessary to know what is happening at the surface and in the air above. Data were therefore required from an upper-air station and a surface station in close proximity. Crawley and Gatwick Airport were chosen for this study with several variables being measured at each station.

Although variables such as 900 millibar wind speed, surface pressure and surface wind speed were analysed as part of the investigation, only those appearing in the final model are described in detail below.

The dependent variable is the maximum day temperature T at Gatwick Airport between 0900 GMT and 2100 GMT. Observations were available for 1096 days during the three-year period 1968 to 1970.

Boyden (1958 and 1962) used the 1000–500 mb thickness as the main predictor variable in his investigations but Inglis (1970) considered the 1000–850 mb thickness so that the results were more directly comparable with those obtained using Gold's method. Since Hawson (unpublished) also suggested use of the 1000–850 mb thickness and it is likely that the relationship with surface temperature will be better for shallow layers near the surface than for deeper ones, this variable was obtained from records at Crawley for the same three-year period.

An important factor in determining the maximum temperature reached during the day is likely to be the state of the sky. Boyden (1962) used the number of hours of sunshine expected during the day to provide an adjustment to the predicted value of the maximum temperature. This is, however, a difficult variable to forecast with any certainty and it was considered that a broad classification of cloud cover could provide a useful, yet simply determined, variable. Lumb (1964) produced a cloud classification which was felt to be too complicated for the present study, therefore a simplification was introduced to give a four-point scale 0–3 for cloud cover, C as defined in Table I.

Table I. *Cloud cover classification (C) for period dawn to 1200 GMT* (C_L = *low-level cloud*, C_M = *medium-level cloud and* C_H = *high-level cloud*).

	Cloud cover classification C
Forecast state of sky throughout the period:	
(a) Predominantly clear: $C_L + C_M \leqslant 3/8$ with or without variable C_H cover	0
(b) Variable $C_L + C_M$, with or without precipitation, or $C_H \geqslant 6/8$	1
(c) Predominantly overcast: $C_L + C_M > 6/8$	2
(d) Predominantly overcast with precipitation (not including odd spots of drizzle)	3
Forecast of fog:	
(a) Only around dawn, clearing to $C_L + C_M \leqslant 3/8$	0
(b) Persisting for any length of time after dawn, clearing to $C_L + C_M \leqslant 3/8$ or fog clearing to variable cloud cover	1
(c) Clearing to $C_L + C_M \geqslant 6/8$	2
(d) Throughout the period	3

3. The prediction model

The data were initially analysed using stepwise regression within months to see if different combinations of variables would provide the best models at different times of the year. However, it was evident from these separate analyses that a strong relationship existed between maximum temperature and 1000–850 mb thickness, h, at all times of the year, with the cloud cover variable being more important during the summer months as was to be expected. This suggested that monthly models of a consistent form, each involving only the two variables thickness and cloud cover, could prove to be reasonably accurate prediction equations.

Consequently a regression analysis was used to fit the equation

$$T = \beta_0 + \beta_1 h + \beta_2 C \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (1)$$

to the data for each month in turn.

The models obtained appeared to fit the data reasonably well.

An examination of the residuals for each model suggested that maximum temperature was also highly time-dependent within the months of March to May (spring) and September to November (autumn). This can be clearly seen in Table II which shows the number of large positive and negative residuals during the first and last ten days of these months.

Table II. *Number of residuals (above one standard deviation from mean) observed during (a) the first and (b) the last ten days of each of the spring and autumn months.*

	Spring			Autumn		
	Mar.	Apr.	May	Sept.	Oct.	Nov.
(a) Positive	3	3	3	11	8	10
Negative	12	5	5	1	2	1
(b) Positive	8	5	7	2	2	0
Negative	1	2	0	2	9	9

In view of this evident time-dependence and also the basic similarity of the monthly models it was conjectured that a single model involving the two variables thickness and cloud cover, together with an adjustment for the time of year, could prove to be reasonably accurate for prediction throughout the whole year.

To assess the seasonal variation in maximum temperature the mean daily maximum temperatures for each month at Gatwick during the years 1959 to 1970 were computed and plotted against time. It appeared that this underlying seasonal variation could be adequately described by a single sinusoid and that a single harmonic introduced into the equation would be sufficient to allow for the seasonal variation in maximum temperature.

The equation

$$T = \beta_0 + \beta_1 h + \beta_2 C + \beta_3 \cos(2\pi t/365) + \beta_4 \sin(2\pi t/365) \quad .. \quad .. \quad (2)$$

was fitted to the data using a regression analysis. In this equation t is the day number starting with $t = 1$ for the first of January. The least-squares estimates of the parameters in this model were obtained to give the prediction equation

$$T = -196.59 + 0.159h - 0.89C - 3.215\cos(2\pi t/365) - $$
$$- 0.206\sin(2\pi t/365) - \quad .. \quad .. \quad .. \quad (3)$$

which had a residual root-mean-square error (RMSE) of 1.51 °C and accounted for 95 per cent of the total variation in the observed maximum temperature over the three years' data. This RMSE compares well with those obtained for the monthly analyses and is smaller than most of the RMSE values in Inglis's (1970) comparison of different prediction methods using only clear summer days at Aughton from 1966 to 1969.

Although this model appeared to be quite a reasonable fit to the data, an examination of the residuals suggested that account should be taken of the interaction between cloud cover and the time of the year. It was evident from the data, and logically reasonable from a practical viewpoint, that the effect of cloud cover on maximum temperature was greater in the summer months than in the winter. To account for this interaction, a cross-product term involving cloud cover classification, C, and day of the year, t, was introduced into the model by adding $\beta_5 C \times D$, where $D = \cos\{2\pi(t+10)/365\}$, to equation (2). This form was chosen for D so that the minimum and maximum values of D occur at $t = 172.5$ and 355, that is on 21/22 June and 21 December, the summer and winter solstices respectively. This will imply that the cloud cover will be most effective at the summer solstice and least effective at the winter solstice.

With this interaction term included in the model the regression analysis gave the prediction equation

$$T = -192.65 + 0.156h - 0.888C - 3.807\cos(2\pi t/365) - \\ -0.179\sin(2\pi t/365) + 0.320C\cos\{2\pi(t+10)/365\} \quad .. \quad .. \quad .. \quad (4)$$

which accounted for just over 95 per cent of the variation in maximum temperature and had a RMSE of 1.49 °C.

Although the extra sum of squares accounted for by the inclusion of the interaction term is not large, it was decided to retain this term in the equation since it represents a logical feature of the meteorological situation and does not over-complicate the model.

In order to use the model in equation (4) to predict maximum temperature it is necessary to estimate the expected 1000–850 mb thickness and to have an assessment of the cloud cover on a particular day of the year. Thus the model may be used for any number of days ahead provided that estimates of thickness and cloud cover are available. This feature makes the model more attractive than others involving lagged temperature that could be developed and probably would be just as accurate.

Substitution of the three values, h, C and t for any particular day into equation (4) is simple enough, but it is even easier to consider the model as if it consisted of two components, a prediction due to the thickness variable and a seasonal adjustment depending on the amount of cloud cover.

The first component, given by

$$T(\text{unadjusted}) = -192.65 + 0.156h, \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (5)$$

is tabulated in Table III. The adjustments necessary to allow for the seasonal effect and amount of cloud cover may be read from Fig. 1. The appropriate adjustment is obtained by entering Fig. 1 with the date and reading the temperature scale according to the particular cloud classification curve.

For example, an estimated thickness of 1325 gpm yields a value for T(unadjusted) of 14.0 °C. The adjustment to add to this value corresponding to a cloud classification 2 on 11 December is −4.7 °C. Therefore an estimate of the maximum temperature in this case would be 9.3 °C.

4. Assessment of the performance of the model

The least-squares estimates of the regression coefficients were based on data measured during 1968–1970. The performance of the model was assessed by comparing the predictions obtained with the observed maximum temperatures during 1978. Data were available for 355 days during that year. The

Table III. *Unadjusted maximum temperature (°C) in terms of 1000–850 mb thickness measured in geopotential metres (gpm).*

Thickness *gpm*	0	1	2	3	4	5	6	7	8	9
1240	0.8	0.9	1.1	1.3	1.4	1.6	1.7	1.9	2.0	2.2
1250	2.3	2.5	2.7	2.8	3.0	3.1	3.3	3.4	3.6	3.8
1260	3.9	4.1	4.2	4.4	4.5	4.7	4.8	5.0	5.2	5.3
1270	5.5	5.6	5.8	5.9	6.1	6.2	6.4	6.6	6.7	6.9
1280	7.0	7.2	7.3	7.5	7.7	7.8	8.0	8.1	8.3	8.4
1290	8.6	8.7	8.9	9.1	9.2	9.4	9.5	9.7	9.8	10.0
1300	10.1	10.3	10.5	10.6	10.8	10.9	11.1	11.2	11.4	11.6
1310	11.7	11.9	12.0	12.2	12.3	12.5	12.6	12.8	13.0	13.1
1320	13.3	13.4	13.6	13.7	13.9	14.0	14.2	14.4	14.5	14.7
1330	14.8	15.0	15.1	15.3	15.5	15.6	15.8	15.9	16.1	16.2
1340	16.4	16.5	16.7	16.9	17.0	17.2	17.3	17.5	17.6	17.8
1350	17.9	18.1	18.3	18.4	18.6	18.7	18.9	19.0	19.2	19.4
1360	19.5	19.7	19.8	20.0	20.1	20.3	20.4	20.6	20.8	20.9
1370	21.1	21.2	21.4	21.5	21.7	21.8	22.0	22.2	22.3	22.5
1380	22.6	22.8	22.9	23.1	23.3	23.4	23.6	23.7	23.9	24.0
1390	24.2	24.3	24.5	24.7	24.8	25.0	25.1	25.3	25.4	25.6
1400	25.7	25.9	26.1	26.2	26.4	26.5	26.7	26.8	27.0	27.2
1410	27.3	27.5	27.6	27.8	27.9	28.1	28.2	28.4	28.6	28.7
1420	28.9	29.0	29.2	29.3	29.5	29.6	29.8	30.0	30.1	30.3

predictions of maximum temperature were derived from actual observations, not predicted values, of thickness and cloud cover. It was realised that this would favourably bias the assessment, since the model has been developed as a forecasting tool, but predicted values, especially for cloud cover, could not be easily assessed from past records. However, the use of actual observations should confirm whether or not the model is highly dependent on the 1968–1970 data.

The predicted maximum day temperatures using equation (4) are shown as the dashed lines in Figs 2(a) and 2(b), superimposed on the observed maximum temperatures. The residual root-mean-square error for these predictions is 1.51 °C which is only slightly larger than that for the three years' data on which the model was developed.

The fit to this independent set of data is very good and suggests that the estimates of the parameters in the model are not highly dependent on the particular data set used to determine them and that the model is generally applicable.

The fluctuations in daily maximum temperature about the underlying seasonal trend are quite large, as may be seen in Figs 2(a) and 2(b) but the adjustments for cloud cover and thickness in the model seem to be able to follow these fluctuations quite well. Meteorological reasons for the larger errors in forecast values were not easily determinable. Those errors which occurred with a particular synoptic situation did not seem to recur in similar situations. Furthermore, an analysis of the residuals against various meterological elements was also inconclusive.

5. Concluding remarks

The prediction model described by equation (3) was developed using stepwise multiple regression analysis applied to various models involving not only the thickness variable and cloud cover classification, but several other variables which were found to contribute insignificantly to the regression sum of squares once the more important variables had been entered into the equation.

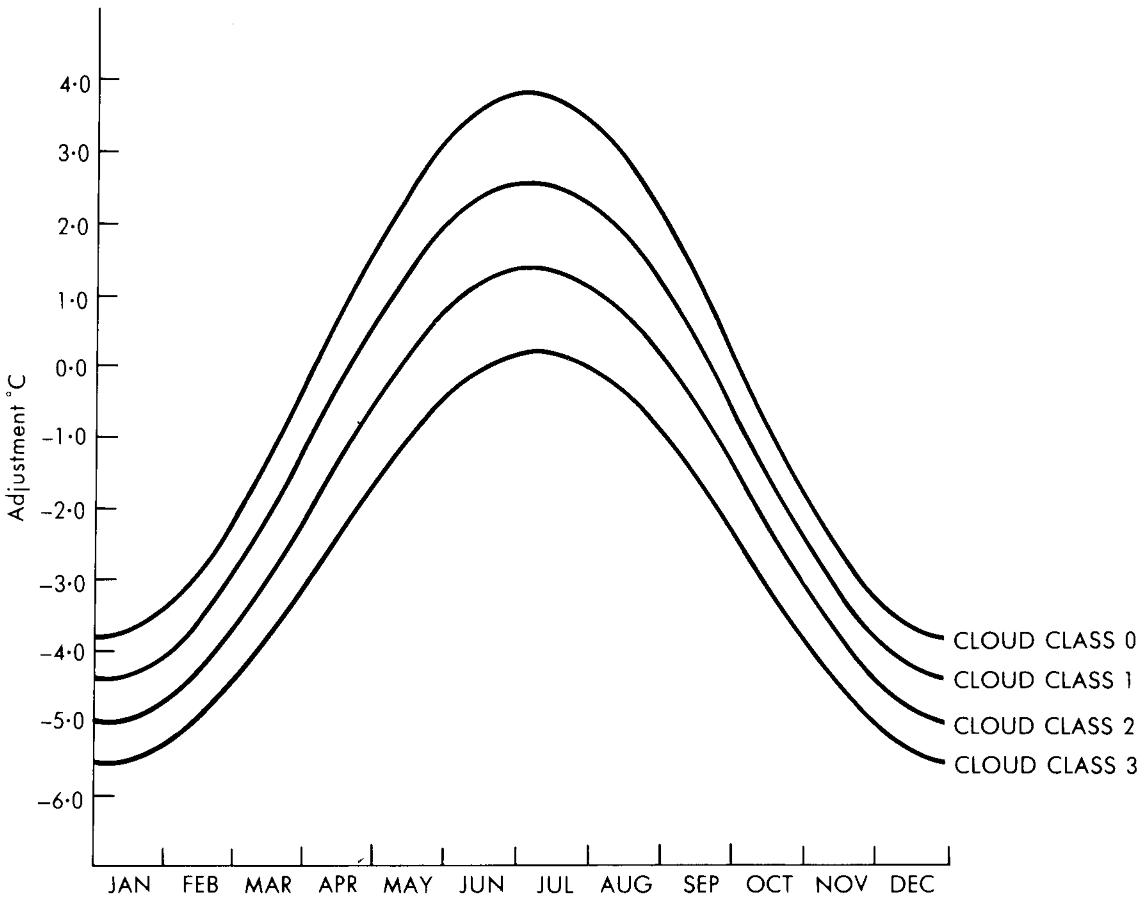

Figure 1. Adjustments to be made to figures in Table III to allow for cloud classification and seasonal effect.

Interactions other than the cloud-time interaction were also examined and found to add little to the analysis.

The resulting equation is reasonably simple to apply and has been found to be quite accurate when used to forecast recent maximum temperatures. Although there is no real evidence to suggest that the model is more, or less, accurate than other methods as a predictor of maximum temperature, the form of the model does allow it to be used throughout the year without any restriction on cloud cover.

Acknowledgement

This work is based on a degree project undertaken by N. S. Callen while employed by the Meteorological Office.

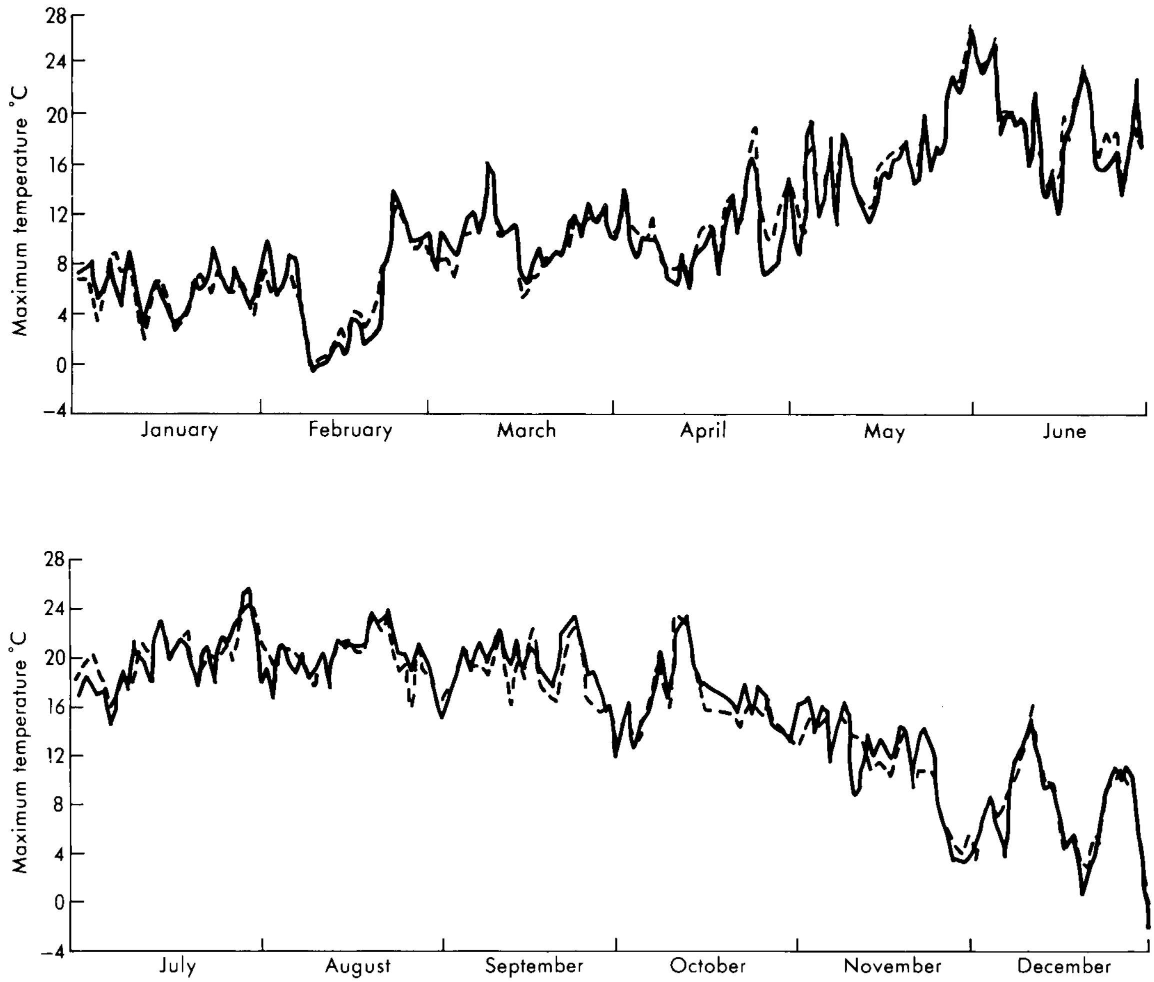

Figure 2. Plots of observed maximum day temperature (full lines) and predicted maximum day temperature (dashed lines) for (a) January to June and (b) July to December.

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551.509.324.2: 551.577.37

Where will the heavy rain occur? — A study of the heavy rain in Northamptonshire on 26 July 1980

By P. F. Waterfall

(Nottingham Weather Centre)

Summary

Methods of forecasting heavy rain are examined in relation to the occurrence of unexpectedly heavy falls in Northamptonshire in an attempt to identify those most useful in locating heavy rainfall.

Introduction

On 26 July 1980 heavy rain occurred on a slow-moving cold front over the Midlands, although little rain was apparent on the synoptic charts. The front was positioned between Benson and Birmingham in the west, and Nottingham, Wittering and Bedford in the east. A report the following day from a farmer near Northampton of '4 inches of rain yesterday' seemed hard to credit.

Synoptic situation

At 0001 GMT a depression was situated just south of Ireland and a cold front extended from north-west Scotland to the Isle of Man thence across Wales to central southern England (Fig. 1).

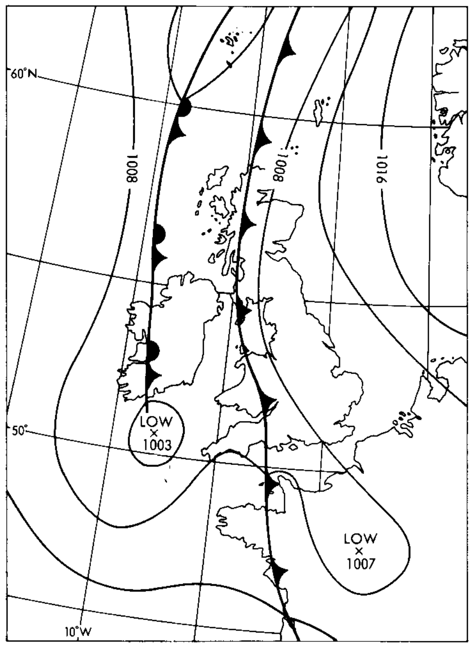

Figure 1. Synoptic situation at 0001 GMT on 26 July 1980.

The 850 mb wet-bulb potential temperature (θ_w) chart for 0001 GMT (Fig. 2) reveals the broad frontal zone lying over England and western France with a tongue of very high values, in the warm air ahead of the front, extending from central France across eastern England. Aloft, the 300 mb contour chart for 0600 GMT (Fig. 3) shows England to be situated between a ridge over Scandinavia and a trough over Biscay, with a jet stream to the north. This is a typical development situation.

Although plenty of thunderstorms were reported, most rainfall was shown as 'intermittent slight' on the synoptic charts and the hourly rainfall amounts showed nothing exceptional.

The cold front was forecast to move slowly north-east across the Midlands during the next 24 hours and outbreaks of rain, heavy and thundery at times, were expected during the day. By 0300 GMT the cold front had advanced to lie from Liverpool to Southampton. Outbreaks of slight rain were being reported at Nottingham Weather Centre and London/Heathrow Airport, all stations to the east being dry.

During the day a small depression moved across south-east England and into the southern North Sea, the cold front becoming slow-moving across the country, roughly along the line of the M1 motorway. The rain finally cleared from the east Midlands between 2200 and 2300 GMT.

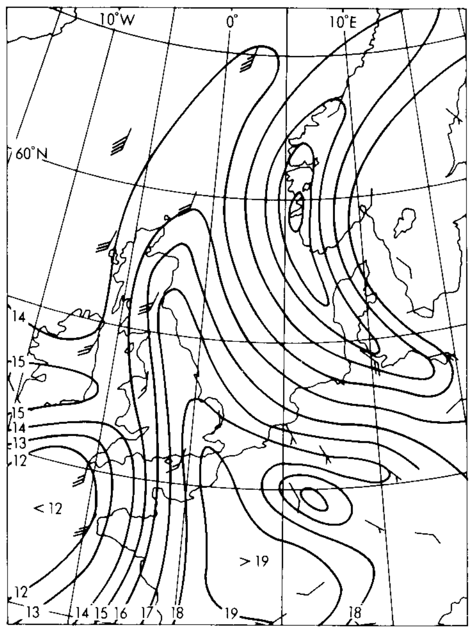

Figure 2. Winds and wet-bulb potential temperature (°C) for 850 mb at 0001 GMT on 26 July 1980.

The rainfall

The period of most intense rainfall occurred between 0500 and 1100 GMT and since this overlaps the two rainfall days (0900–0900 GMT), the 48-hour period was taken as a whole. There was no significant rain before or after that associated with the cold front under review (the occlusion over Ireland became insignificant). From 0001 to 2400 GMT on 26 July the total rainfall as reported by Meteorological Office stations in the Midlands was:

Nottingham Weather Centre	17.2 mm
Birmingham Airport	3.9 mm
Gloucester	1.2 mm
Brize Norton	9.8 mm
Benson	21.3 mm
Bedford	18.1 mm
Wittering	2.6 mm

The maximum reported hourly fall early in the day of 6.4 mm occurred at Brize Norton between 0400 and 0500 GMT. Thus the synoptic reports did not suggest any very heavy falls prior to the events in Northamptonshire.

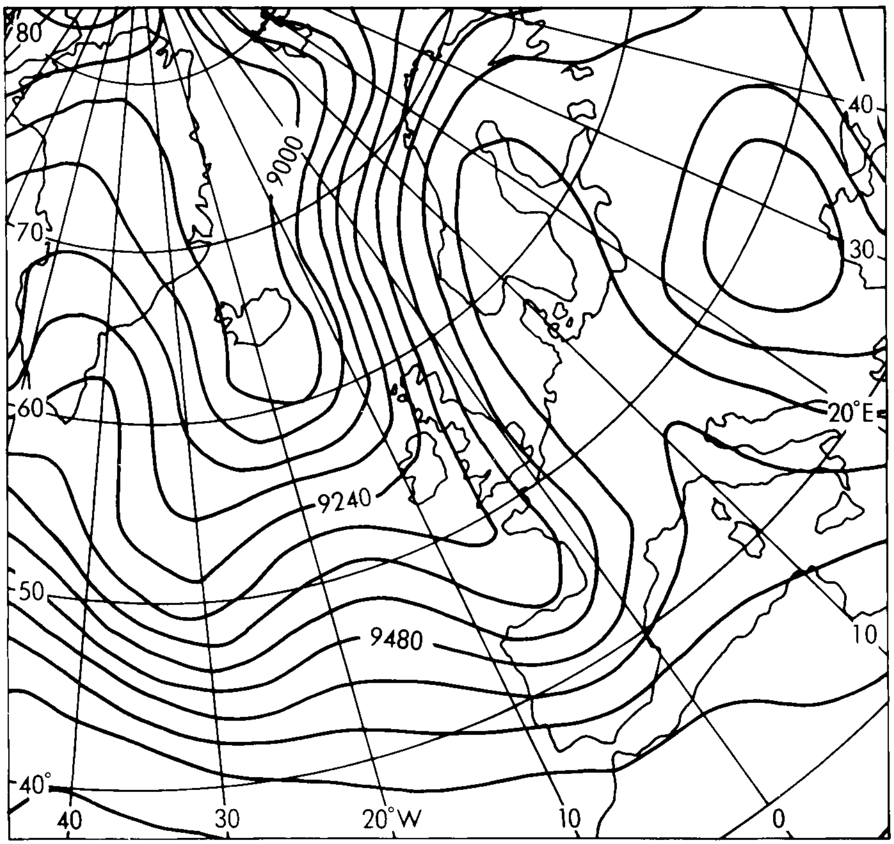

Figure 3. Central Forecasting Office 300 mb analysis for 0600 GMT, 26 July 1980. Values in geopotential metres.

The heaviest rainfall discovered in the area was the 100.4 mm (3.95 in) already mentioned — caught by Mr Turney at Brixworth. He measures his rainfall by collecting the rain in a glass jar under a 5-inch funnel. Normally readings are taken at 0600 local time but on this day the rainfall was so intense that Mr Turney was fearful his jar would overflow and measured the contents several times during the day. He must have lost some rainfall while so doing, and thus the actual fall would have been slightly greater. Between 0500 and 0930 GMT he collected 68.6 mm (2.7 in) of rain, and there was a further 19.1 mm (0.75 in) in the following hour. The amount is confirmed by the 100.1 mm recorded by the Anglian Water Authority gauge at Pitsford Reservoir which is about 3 km south of Brixworth, and the 93.4 mm (3.7 in) at Hollowell which is about 6 km west of Brixworth. A map showing the 2-day total falls surrounding the Northampton area between 0900 GMT on 25 July and 0900 GMT on 27 July 1980 is shown at Fig. 4. Rainfall records at Brixworth have been kept by the Turney family since 1915 and this was the biggest daily rainfall that they had ever measured. July 1980 also turned out to be the wettest month that they had ever recorded on their farm.

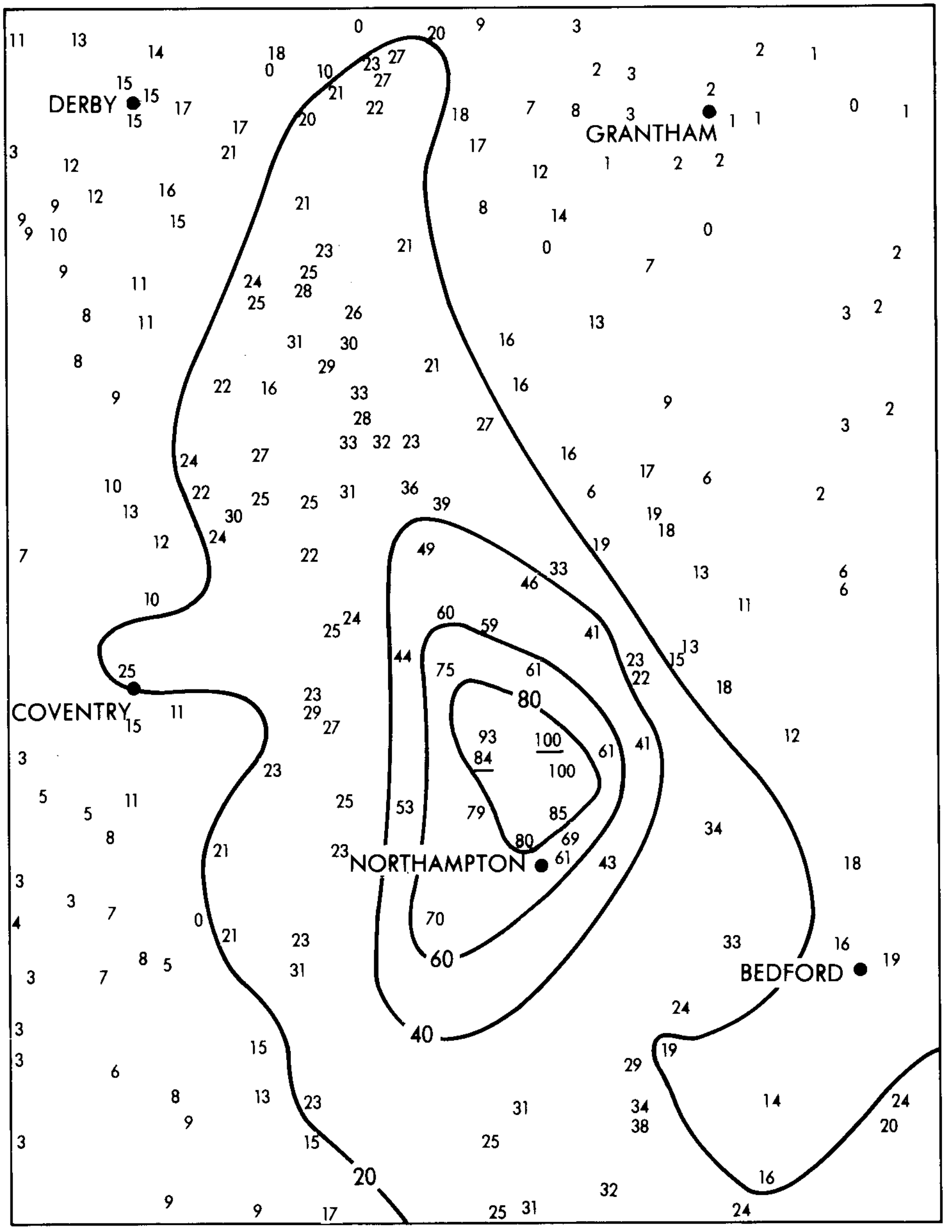

Figure 4. Total rainfall (mm) from 0900 GMT, 25 July to 0900 GMT, 27 July 1980. (The reports from Brixworth Farm and Ravensthorpe Reservoir are underlined.)

The most intense rainfall occurred quite early in the storm, 13 mm in 5 minutes being measured by recording rain-gauges belonging to the Anglian Water Authority at Stimpson Avenue, Northampton, between 0540 and 0545 GMT, and at Ravensthorpe Reservoir, which is about 7 km west of Brixworth, between 0530 and 0535 GMT. Rainfall amounts for each 5-minute period between 0500 and 1400 GMT at Ravensthorpe are shown in Fig. 5.

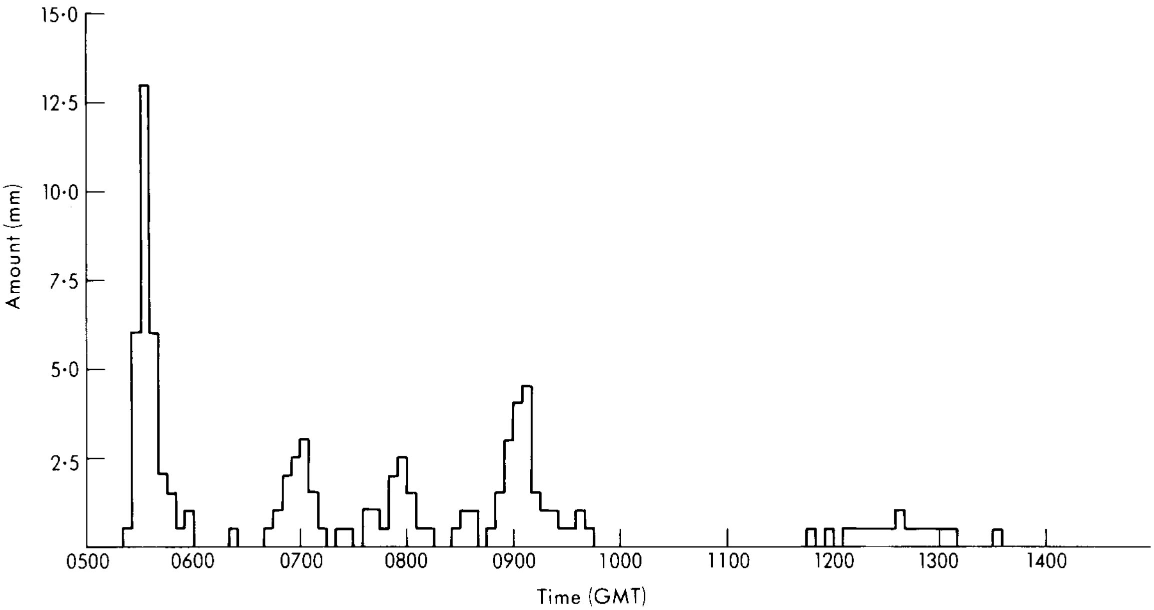

Figure 5. Rainfall amounts for each 5-minute period for Ravensthorpe Reservoir from 0500 to 1400 GMT on 26 July 1980. (Total rainfall 83.5 mm.)

Although the amounts of rain decreased later in the day and away from the Northampton area, data from other recording rain-gauges kindly supplied by the Severn–Trent, Anglian and Thames Water Authorities show a similar pattern with a short heavy burst followed by a period of mainly light rain.

The rainfall caused severe flooding in Northampton and some of the surrounding villages, and produced the highest summer flows ever recorded on the River Nene. A detailed report of the hydrological aspects of this rainfall was produced by the Welland and Nene River Division of the Anglian Water Authority (1980) and contains details of the calculated return periods for these events, some of which are in excess of 100 years; these correspond well with the readings taken at the farm.

Forecasting techniques

The *Handbook of weather forecasting* (Meteorological Office 1975), Chapter 19, section 19.7, lists those aspects to be considered when forecasting rain and many were relevant here.

Local rules for forecasting heavy rainfalls in the Trent River area in use at Nottingham Weather Centre require a depression or wave-tip over southern England, the warm air dew-point to be 4 °C or more above normal (i.e. 16 °C or higher in July) and minimum pressure at Nottingham Weather Centre to be less than 1005 mb during the rainfall day. The synoptic situation and dew-point criteria both apply to this case.

Amongst their conclusions, Ogden and Gray (1971), writing on heavy falls of rain at London Weather Centre, also draw attention to the passage of a surface low across the area, a significant association with active cold fronts, and the contribution of convective instability in the warm air. All three of these apply in this case. (The 0001 GMT radiosonde ascent for Crawley is shown at Fig. 6.)

The *Handbook of weather forecasting*, Chapter 19, suggests that for the occurrence of 'severe local storms', as described by Browning and Ludlam (1962), we require:

(i) A supply of warm moist air at low levels, i.e. high values of surface wet-bulb potential temperature (θ_w), typically about 20 °C, but the possibility of severe storms should be considered if θ_w exceeds 17 °C.

(ii) Great depth of instability.

(iii) Great buoyancy, indicated by a large excess of θ_w over the saturation wet-bulb potential temperature (θ_s) in the middle and upper troposphere.

(iv) Vertical wind shear, typically a veer with height throughout the convective layer. The convective layer is the entire troposphere for 'severe local storms', and shear between the ground and the 500 mb level is usually in the range 30–60 knots. Shear of the order of 30 knots in the lowest 150 mb (intense warm advection) is particularly favourable for storm formation.

(v) Trigger action, namely daytime surface heating, low-level convergence, or orographic uplift.

The 0001 GMT Crawley radiosonde ascent (Fig. 6) gives a value of θ_w between 17 and 18 °C, and there are potentially unstable layers from about 6000 to 24 000 ft. The average value of θ_s in these layers is between 17 and 18°C, very similar to the surface θ_w, but an inversion extends from the surface to 1000 ft and θ_w at this level is 20 °C. This ascent is fairly typical of a situation where heavy thundery rain could occur when the instability is released by convergence.

The upper-air soundings available on this day are not particularly helpful in assessing the wind shear, the nearest (Crawley) being about 140 km south-south-east of the heavy rain area. Analysis of the 0001, 0600 and 1200 GMT variations at Crawley, Hemsby and Aughton suggests that the criteria of a veer with height and a change of 30–60 kn in the wind speed between the ground and the 500 mb level could have been met in Northamptonshire, where surface winds were light and mainly north-easterly to the north of the small secondary depression between 0300 and 0600 GMT. The convergence associated with the formation of the small surface depression could provide the trigger action.

Grant (1980) draws attention to the work of Miller (1972) and Crisp (1979) in America on severe weather forecasting, and the parameters that they use suggest lines along which further investigations into synoptic techniques could proceed. However, the general lack of data west of the British Isles would inhibit some of their methods. Their ideas relating to the intersection of significant lines (frontal, convergence, moisture, etc.) seem likely to be most relevant, and accordingly a number of mesoscale analyses have been done by the Special Investigations Branch and the author to see if they would have been effective in this case. The 0600 GMT synoptic chart (Fig. 7) shows the situation shortly after the time of maximum rainfall. A mesoscale anticyclone is moving south-eastwards ahead of the advancing cold front, blocking and retarding it. This slowing down is producing local prolongation of the thundery rainfall associated with the front. The anticyclone is combining with the north-eastward movement of the small secondary low to produce the maximum low-level convergence in the warm air just ahead of the front. It is noteworthy that this is in the Northampton area.

No really significant contributions from moisture patterns were found in this case.

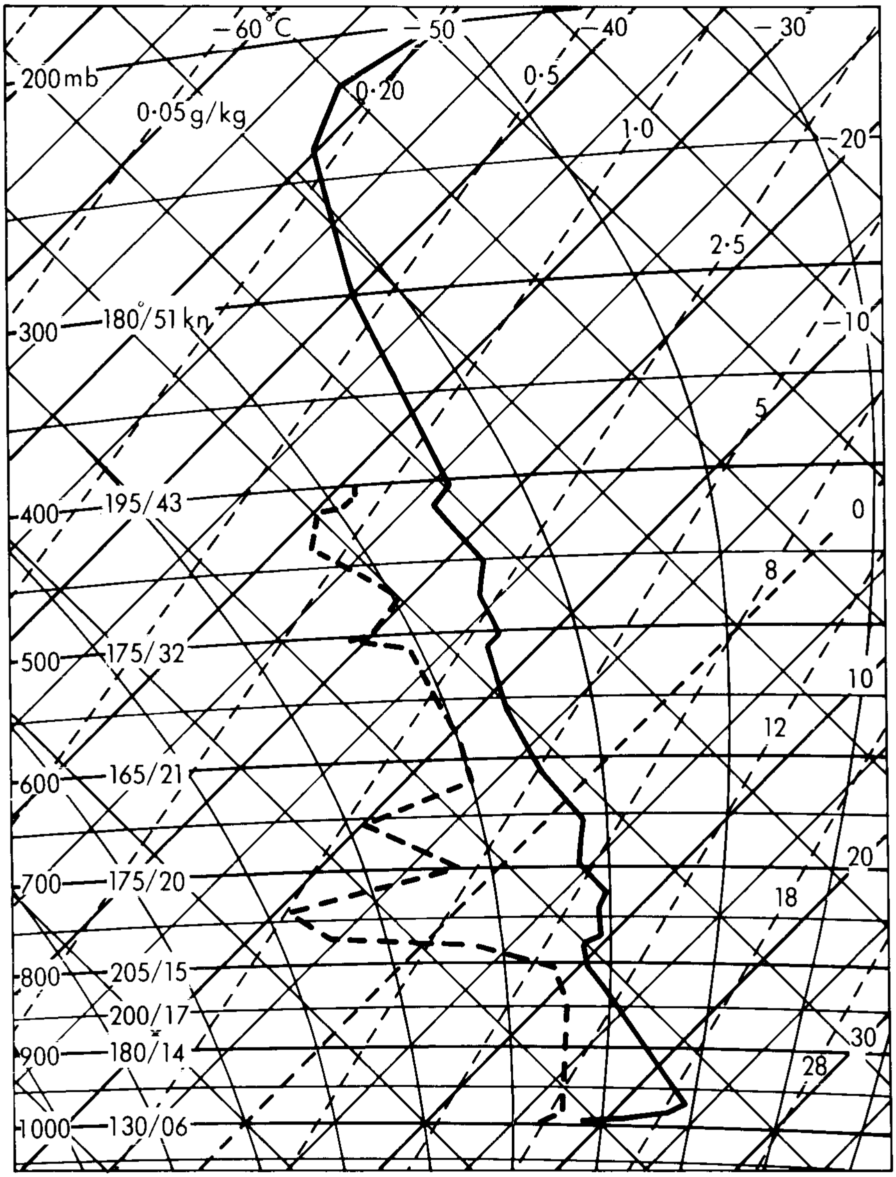

Figure 6. Tephigram for Crawley, 0001 GMT on 26 July 1980.

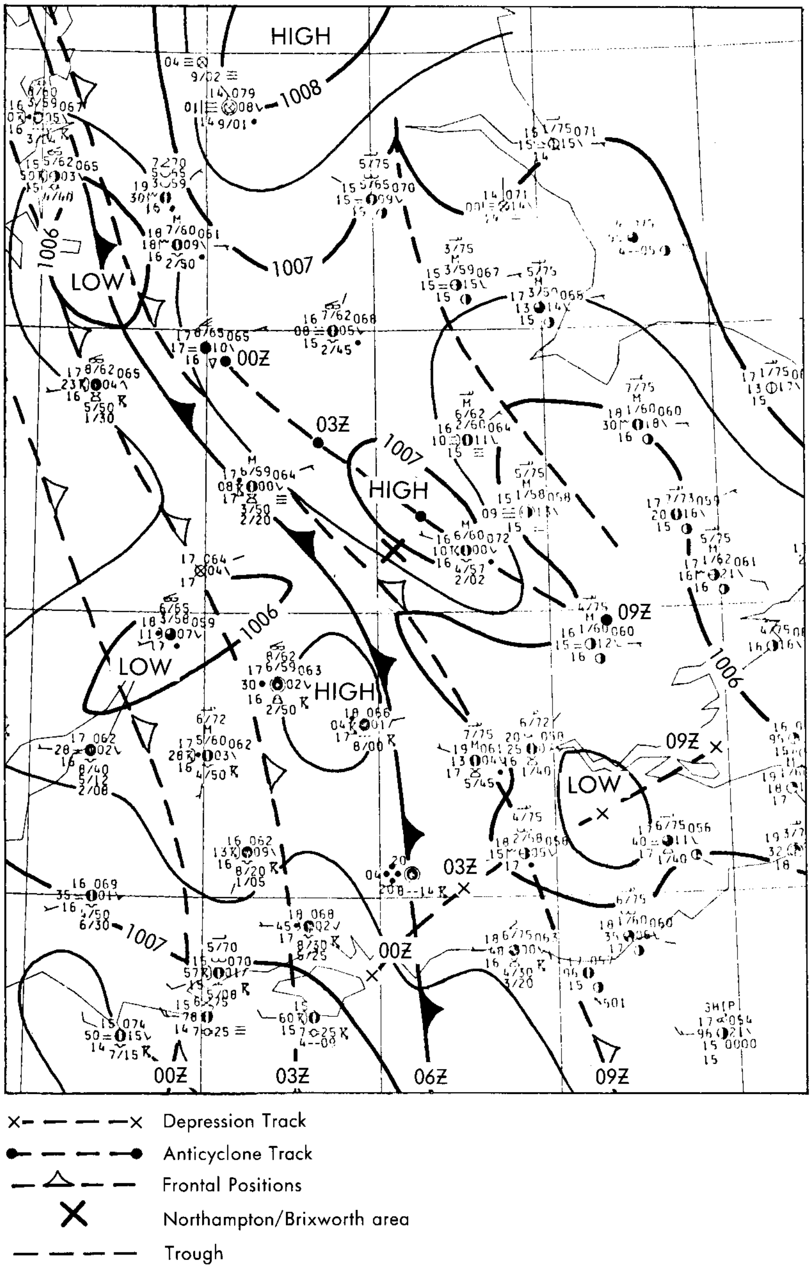

Figure 7. Surface analysis for 0600 GMT, 26 July 1980.

Conclusions

The forecasting techniques described earlier enabled the duty forecaster to provide a correct forecast of 'heavy rainfall in places' on that day, but none of it would have enabled the synoptic forecaster to provide specific and successful forecasts of the events in Northamptonshire, and the non-events elsewhere, although the Trent area heavy-rainfall rules, the mesoscale analyses and the criteria for the formation of severe local storms give some clues to why it occurred. However, it is suggested that the rules in use for the Trent area need to include a mention of the significance of areas just ahead of an active cold front. The need for careful analyses of synoptic data in these situations is also apparent.

It would seem likely from the reports by Browning (1980) and Browning *et al.* (1980) that the Areal Rainfall Radar systems now being introduced will be much more successful than synoptic techniques in dealing with occurrences of heavy rainfall, particularly where they are localized, although a major drawback is that they can only come into operation when the heavy rain commences. Radar data provided by the Meteorological Office Radar Research Laboratory at Malvern for 26 July 1980 show an area of heavy rain moving north-eastwards into Northamptonshire between 0430 and 0600 GMT, with maximum rainfall rates in the Northampton–Brixworth area between 0530 and 0600 GMT in excess of 120 mm/h. The radar picture for 0600 GMT (Fig. 8) shows the area of maximum rainfall just clearing the Northampton area.

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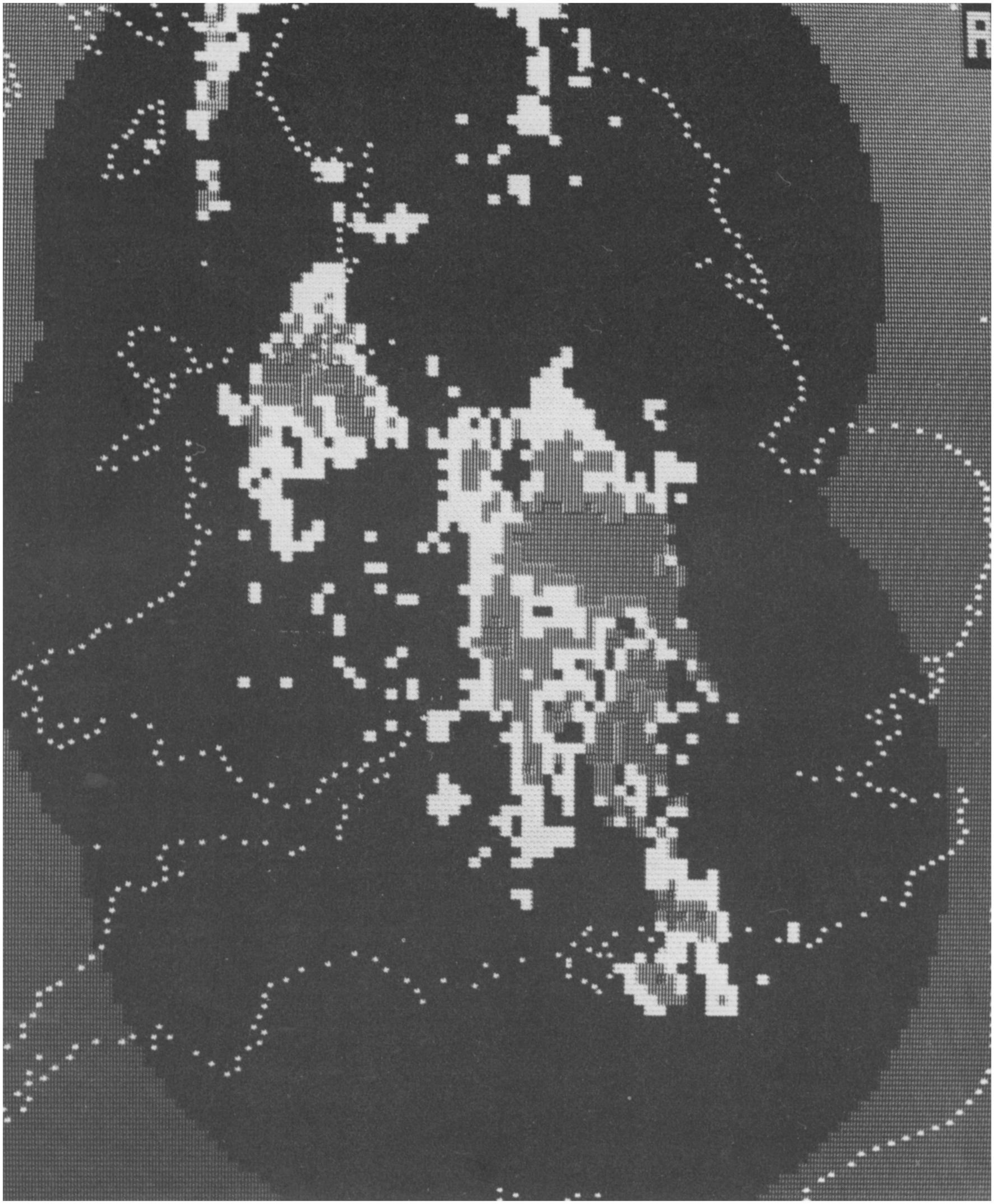

Figure 8. Rainfall radar display, 26 July 1980 at 0600 GMT. (Black represents 0 mm h^{-1}, white < 2 mm h^{-1}, light hatching < 8 mm h^{-1} and dark hatching $\geqslant 8$ mm h^{-1}.)

Notes and News

100 years ago

The following extract is taken from *Symons's Monthly Meteorological Magazine*, March 1882, **17**, 26.

DENSE FOG AND BLACK RAIN IN THE ISLE OF MAN.

To the Editor of the Meteorological Magazine.

SIR,—A few notes on the fog of Tuesday, February 7th, may be interesting to some of your readers. In the morning the fog gradually crept up from the sea. About noon it became very dense, assuming a yellow tint which gradually deepened into a greenish black, and from 2 to 2.30 p.m., we were enveloped in almost absolute darkness. During this remarkable half hour, a heavy shower of rain and hail fell yielding ·12 in., which on being examined proved to be quite black and to be loaded with minute particles of carbon, which, even after standing for 48 hours, did not fall to the bottom. These black particles were no doubt wafted to us from the "black country" in England and were retained in the atmosphere by the abnormally high barometric pressure which has prevailed so long (*i.e.* the atmosphere was heavy enough to retain these particles which would under ordinary conditions have fallen to the ground). At 2.30 the darkness began to decrease and the fog gradually departed in a northerly direction. From the reports of various correspondents in different parts of the Island I have been able to trace its course—at Port Erin and Castletown there was nothing but a mist; at St. John's and Kirk Michael it was dull and a few drops of rain fell, but there was no fog, while the mountains were enveloped in it; so it was confined to the eastern side of the mountains. At Ramsey there was dense fog with soft hail and rain about 3 p.m., when the gas had to be lit in the shops. Two huge black columns of cloud passed over Andreas and Bride between 3.15 and 4 p.m., and it rained briskly at the same time, but the fog was not very dense. All the "oldest inhabitants" I have "interviewed" combine in saying that they never witnessed such a phenomenon before in the Isle of Man, and this must be my excuse for writing at such length.

Yours truly,

Cronkbourne, Isle of Man, Feb. 23, 1882. A. W. MOORE.

Obituary

We regret to record the death on 28 November 1981 of Mr J. G. Moore, Principal Scientific Officer, deputy to the Assistant Director (Central Forecasting). John Moore, a graduate of London University, joined the Office in 1951 and after his initial training was posted to the Upper Air Climatology Branch at Harrow where, during the next three years, he collaborated with Miss Austin and Mrs Goldie in the preparation of Geophysical Memoir No. 103, Upper Air Temperature over the World. On promotion to Senior Scientific Officer in 1956 he moved to the Central Forecasting Office at Dunstable to begin his long association with operational forecasting work. In 1960 he joined the Dynamical Research Branch for a period, but in 1962 returned to the bench, this time at London (Heathrow) Airport. In 1966 he was promoted to Principal Scientific Officer and rejoined the Central Forecasting Office (now at Bracknell) where, apart from two years in the Special Investigations Branch, he remained for the rest of his life, becoming one of the most experienced Senior Forecasters in the Office; latterly, he was engaged in Branch administration and planning. In 1959 John Moore married one of his colleagues, Elizabeth Walsh, who herself had worked at Harrow and Dunstable.

John Moore had an excellent and well-trained bass-baritone voice which he used to give pleasure to a large number of people; he performed at Office concerts and with amateur operatic societies, and was also a member of various small vocal groups who went round east Berkshire entertaining the residents of old people's homes and other institutions. He was an active churchman, and was a churchwarden and member of the parochial church council of All Saints, Ascot.

John Moore was much liked by all who knew him, was hard-working and had a merry sense of humour; he will be much missed by all his friends and colleagues.

THE METEOROLOGICAL MAGAZINE

No. 1316 March 1982 Vol. 111

CONTENTS

	Page
Retirement of Dr N. E. Rider	49
Forecasting daily maximum surface temperature from 1000–850 millibar thickness lines and cloud cover. N. S. Callen and P. Prescott.	51
Where will the heavy rain occur?—A study of the heavy rain in Northamptonshire on 26 July 1980. P. F. Waterfall	58
Notes and news	
100 years ago	69
Obituary	69

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 RG12 2SZ and marked 'For Meteorological Magazine'.

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