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THE ACCURACY OF LONG-RANGE FORECASTS ISSUED BY THE METEOROLOGICAL OFFICE

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

The twice-monthly publication of forecasts for a month ahead in '*Monthly Weather Survey and Prospects*' commenced in December 1963. The accuracy of each forecast is assessed by a panel of meteorologists and the results from the first 33 months are summarized below. Each forecast contains statements about the expected mean temperature and the total rainfall for the whole month together with additional information on type of weather and incidence of such things as snow, frost or thunderstorms.

The expected mean monthly temperature is given as one of the five categories : much above average, above average, near average, below average or much below average. The limits for these categories have been chosen such that in the period 1931–60 each category occurred equally frequently. The category boundaries therefore vary a little from month to month and from one part of the country to another. Some typical values for London and Edinburgh are given in Table I.

TABLE I—DIFFERENCES OF MONTHLY MEAN TEMPERATURE FROM THE 1931–60 AVERAGE FOR EACH FORECAST TEMPERATURE CATEGORY

Temperature category	London (Kew)				Edinburgh (Blackford Hill)			
	Jan.	Apr.	July	Oct.	Jan.	Apr.	July	Oct.
				degrees Celsius				
Much above Average	>1·7	>1·1	>1·2	>0·9	>1·4	>1·1	>0·7	>0·9
Above Average	1·7 to 0·8	1·1 to 0·6	1·2 to 0·4	0·9 to 0·2	1·4 to 0·3	1·1 to 0·4	0·7 to 0·2	0·9 to 0·4
Near Average	0·7 to −0·3	0·5 to −0·4	0·3 to −0·3	0·1 to −0·3	0·2 to −0·2	0·3 to −0·3	0·1 to −0·3	0·3 to −0·3
Below Average	−0·4 to −1·4	−0·5 to −1·1	−0·4 to −1·0	−0·4 to −1·1	−0·3 to −1·3	−0·4 to −1.3	−0·4 to −0·7	−0·4 to −0·9
Much below Average	<−1·4	<−1·1	<−1·0	<−1·1	<−1·3	<−1·3	<−0·7	<−0·9

A forecast of rainfall is given in a similar way as one of three equally likely categories, above average, near average or below average. The limits are expressed as percentages of the average monthly rainfall and Table II shows some values for London and Edinburgh.

TABLE II—PERCENTAGES OF THE 1931–60 MONTHLY AVERAGE RAINFALL FOR EACH RAINFALL CATEGORY

Rainfall category	London (Kew) Jan.	Apr.	July	Oct.	Edinburgh (Blackford Hill) Jan.	Apr.	July	Oct.
				percentages				
Above Average	>110	>116	>119	>117	>115	>117	>107	>120
Near Average	110 to 65	116 to 72	119 to 71	117 to 79	115 to 83	117 to 70	107 to 76	120 to 67
Below Average	<65	<72	<71	<79	<83	<70	<76	<67

The temperature and rainfall forecasts are checked separately for each of the 10 regions of the British Isles shown in Figure 1. Initially one station

FIGURE 1—FORECAST REGIONS OF THE BRITISH ISLES

in each area was taken as representative, but for most of the period average values for each area have been calculated from stations which appear in the *Daily Weather Report.** The mean temperature for the month is calculated from the average of the daily maxima and minima, and the area mean anomaly is found as the average of the anomalies of the stations in the area. The rainfall at each station is expressed as a percentage of its normal (1931–60), and these percentages are averaged to give the area mean for the month. These calculations, and numerous others needed for routine long-range forecasting and research, are carried out on the COMET computer using a very versatile general-purpose programme.[1]

The preparation of monthly normals of temperature and rainfall for the period 1931–60 presented difficulties in respect of some of the 44 checking stations used which had not been reporting for the whole of this period, but representative figures were obtained by adjusting values from nearby stations. Figures for mid-month to mid-month periods were not available, so normals for these periods were obtained by interpolation from the monthly figures. The monthly data were subjected to harmonic analysis ; smoothed values for both the whole month and mid-month to mid-month periods were then calculated using the first two terms of the harmonic series. The quintile boundaries of the temperature categories and the rainfall terciles were calculated in this way as well as the area normals.

A score for each area is calculated according to the tables shown in Table III.

TABLE III(*a*)—SCORES FOR TEMPERATURE FORECASTS

ACTUAL	FORECAST				
	Much below	Below	Average	Above	Much above
Much below	4	1	−3	−4	−4
Below	2	4	1	−2	−2
Average	0	1	4	1	0
Above	−2	−2	1	4	2
Much above	−4	−4	−3	1	4

TABLE III(*b*)—SCORES FOR RAINFALL FORECASTS

ACTUAL	FORECAST		
	Below	Average	Above
Below	4	−2	−4
Average	0	4	0
Above	−4	−2	4

In a sample of situations which has about equal frequency of occasions in each category the average score for a random forecast will be zero, as will be the average score for a climatological forecast, i.e. always forecasting the normal. Each correct forecast scores four points. Temperature forecasts which are one category (out of five) wrong have a small positive score, but all other errors have negative or zero scores.

From the scores for each area an average score for the whole country is calculated and is used to provide an assessment of the accuracy of the forecast as one of the following categories :

A No serious discrepancy
B Good agreement
C Moderate agreement
D Little agreement
E No real resemblance.

* London, Meteorological Office. *Daily Weather Report.* London, HMSO.

The scores corresponding to each category are not rigidly laid down, as some account is taken of the pattern of temperature anomaly and rainfall as shown by the individual stations. If for instance the gradient of temperature anomaly is correctly forecast as relatively warm in the north-west and cool in the south-east but the dividing line is wrongly positioned this is considered superior to a forecast which gained a slightly higher score by having some areas correct in a wrongly orientated pattern. Scores allotted to each category have been : *A* 4·0 to 2·2, *B* 2·4 to 1·0, *C* 1·4 to −0·2, *D* 0 to −1·5, *E* −1·2 to −4·0.

The assessment of the accuracy of the additional information about weather types and snow, etc., is necessarily a more subjective matter. Such phenomena as thunderstorms, fog and frost are normally included in the forecast only if they are expected to be notably more or less frequent than usual. No credit is given for statements that are little more than climatology. Each statement in the forecast is considered separately by the panel and a mark *A–E* awarded to it and then a single mark for the additional information as a whole is given. Finally the marks for temperature, rainfall and additional information are compounded to give an overall mark of the accuracy of the forecast as a whole. Table IV shows the frequency with which the various assessments were made in the 33-month period since December 1963.

TABLE IV—NUMBER OF FORECASTS FALLING IN VARIOUS CATEGORIES OF SUCCESS. PERIOD—DECEMBER 1963 TO AUGUST 1966

Category	Mean Temperature	Rainfall	Additional Information	Overall Marking
		Number of forecasts		
A = No serious discrepancy	10	10	12	1
B = Good agreement	24	10	17	24
C = Moderate agreement	12	20	19	23
D = Little agreement	8	17	14	15
E = No real resemblance	12	9	4	3

An overall marking of at least moderate agreement was obtained on 73 per cent of occasions. It was rare for forecasts of temperature, rainfall and additional information simultaneously to be very good or very bad, so that overall marks of *A* or *E* were few.

Good forecasts of temperature were made more often than good forecasts of rainfall. This is in agreement with the experience of short-range forecasters that rainfall is the more difficult element to predict precisely. In the 66 forecasts made for each of 10 areas the temperature category was exactly right 170 times (26 per cent) and only one wrong (out of five) 280 times (42 per cent), compared with chance expectation of 20 per cent and 32 per cent respectively ; thus 68 per cent of temperature forecasts were correct or about correct. The correct rainfall category (out of three) was forecast 237 times (36 per cent) ; 51 per cent of the forecasts were one category wrong and the remainder, 13 per cent, two categories wrong. This is an improvement on the chance expectation of 33, 45 and 22 per cent respectively ; there is a useful reduction in the large errors but the overall improvement is not great.

The middle categories of both temperature and rainfall were forecast too often, and the extreme categories too rarely. In fact temperatures much below average and much above average were forecast on only 4 per cent and 3 per cent of occasions, whereas they occurred on 29 per cent and 9 per cent of occasions respectively. Average rainfall was forecast 49 per cent of the time but occurred on only 35 per cent of occasions.

All forecasts included information on the general weather type or the incidence of wet and dry spells or warm and cold intervals, and about 60 per cent of this information was considered of definite value. Other items which received specific mention were :

	Number of mentions	Number substantially correct
Frost	26	17
Snow	20	15
Fog	11	9
Thunderstorms	11	8

Previous experience had shown that autumn was the most difficult season in which to make monthly forecasts and this was borne out in the past 33 months. Of the autumn forecasts 58 per cent received overall marks of *D* or *E* ; nevertheless the only forecast to receive an overall mark of *A* was an autumn one. Summer had fewest poor forecasts, three *D*'s out of 18 forecasts.

The foregoing results cannot engender complacency in our long-range forecasters, but they do represent a solid achievement. As techniques are refined we can hope for a gradual increase in the detail included and perhaps a small improvement in accuracy, but advances will necessarily be slow.

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551.509.21:551.577.21

A NOTE ON THE USE OF HOURLY RAINFALL OBSERVATIONS

By D. E. JONES

Introduction.—Since May 1965 quantitative observations of rain have been made hourly by 63 meteorological offices in the United Kingdom and distributed over the teleprinter network for use in forecasting. This note has been written to assist in the interpretation of these observations and to indicate how they can be used.

'Present weather' observations.—A statistical investigation has shown that although the 'present weather' observations reported in the SYNOP code give some indication of the amount of rain that has fallen in the previous hour, the range of rainfall amounts corresponding to any given code figure is extremely wide, making it difficult to assess how much rain is in fact falling from a system. The main reason for this wide spread of values is that the reported rain intensity is assessed for a ten-minute interval at the time of observation and no account is taken of the precipitation intensity in the 50 minutes since the previous (hourly) report. Thus it is quite possible for a considerable amount of rain to have fallen at a station reporting 'slight rain' or 'rain in the past hour'. Also a station reporting 'continuous heavy rain' may have had for example as little as 0·5 mm or as much as 10 mm in the previous hour. A further factor increasing the spread of values is that the rates of rain are often subjectively assessed and reported on a rather crude three-class scale.

The 'present weather' reports are useful for determining the general level of activity of a large rain system provided enough observations are available, but they are not adequate for describing precipitation patterns in the detail required for short-period forecasting of rain, quantitative or otherwise.

Quantitative observations of rainfall naturally give a better indication of the intensity of rain systems particularly when only a few observations are available, and it is also found that details in the rain patterns are easier to follow than when using 'present weather' reports alone. They also have the advantage that they are easier to summarize when forecasts are being verified. However, 'present weather' reports of precipitation are unlikely to be completely replaced by quantitative values, since they indicate the character of the precipitation and because they are easier observations to make, requiring no apparatus.

Interpretation of hourly values for short-period forecasting.—Quantitative rainfall observations suffer from a number of peculiarities not found with other meteorological variables. Because they are cumulative in character they are subject to spurious variations if the time interval between observations departs greatly from one hour. In particular an unexpectedly large value at one hour following a zero or nil observation should be viewed with suspicion (especially if the zero value itself was unexpected) since it may represent an accumulation of more than one hour. It is also important to differentiate between reports of 'no rain' and missing reports.

When a narrow belt or area of rain crosses a region, the sequence of hourly values observed at a station will depend on how the period of rain is distributed with respect to the observing times, e.g. a period of rain lasting one hour may be reported as one large amount at one hour or as two smaller amounts at two consecutive hours. Thus the apparent intensity of such a system will fluctuate from hour to hour by a factor as large as 2.

Since the observations refer to rain in the whole of the previous hour, rain apparently falling behind a moving front may actually have all fallen ahead of it and the faster the front moves, the more marked this effect becomes. The 'present weather' observations help to clarify this point.

Use of quantitative values.—The large variations in rainfall that occur on a short space- or time-scale are a constant source of difficulty when studying or forecasting rain. These variations may be orographic (or topographic) in origin or may be due to the presence of meso-scale rain-producing dynamical systems which apparently often occur in the rain area of larger systems.

Isolated thundery outbreaks often travel across the country as meso-scale systems and can be tracked by using 'present weather' observations on the usual large-scale synoptic charts. If quantitative values are also used it is found that the main centres of activity are defined more satisfactorily (although the details usually move in an irregular way) and a much better idea is obtained of the intensity of the storms.

Studies of hourly rainfall observations show that in widespread frontal or cyclonic rain it is often possible to discern lines or cells of more intense rain 50 to 150 miles in extent which move fairly continuously from one chart to the next and have a lifetime of several hours. An example is given in a later section ; others are illustrated by Wallington.[1]

Unfortunately little is known about the types of feature that can occur or about their life-history ; their progress may be obscured by the presence of convection or by the effects of topography, but since they have a life of several hours it is important for the forecaster to be able to detect them and to forecast their movement and development for a few hours ahead.

For this purpose the observations are best plotted on a large-scale chart ($1 : 3 \times 10^6$) onto which the positions of fronts, pressure troughs and centres have been marked. It will be found that rough isopleths of rainfall can be drawn provided the interval between the isopleths is not too small. The series of isopleths for amounts $\leqslant 0{\cdot}1$, 1, 2, 4, 8, 12, $\geqslant 16$ mm has been found satisfactory in most cases, although when the amounts are small a line for 0·5 mm is useful. At the advancing edge of widespread rain, especially ahead of a warm front, the distribution of traces and 0·1 mm is usually very irregular and it is often preferable not to enclose these observations by an isopleth unless they are closely associated with larger values.

The drawing of isopleths over the British Isles (Figure 1) is usually rather subjective, especially for example over Wales, the west Midlands and Sussex, where there are but few observations. Great attention needs to be paid to maintaining continuity with previous patterns which may require re-drawing in the light of later observations.

The 'present weather' observations can be called upon for filling some of the gaps and they may be interpreted in a rough quantitative way by using Table I, which was derived from a statistical analysis of observations of 'present weather' and hourly rainfall.

When 'present weather' reports corresponding to small amounts of rain are associated with those corresponding to larger amounts, the former are likely to represent higher amounts than are given in Table I. When the estimates based on this table are not in agreement with the plotted quantitative values the latter should be adopted. It must be emphasized that the range of hourly values corresponding to a given code number is very wide.

TABLE I—QUANTITATIVE INTERPRETATION OF 'PRESENT WEATHER' OBSERVATIONS OVER THE BRITISH ISLES

Examples of code figure for present weather	Meaning of code figure	Suggested values of hourly rainfall
60	intermittent slight rain	not significant, i.e. <0·1 mm
61	continuous slight rain	not significant if isolated, otherwise 0·1–0·5 mm
62	intermittent moderate rain	0·5–1·0 mm
63	continuous moderate rain	1·0–2·0 mm
64	intermittent heavy rain	about 2·0 mm but covers a very wide range of values
65	continuous heavy rain	> 2·0 mm
80	slight rain shower(s)	not significant if isolated, otherwise 0·1–0·5 mm
81	moderate or heavy rain shower	> 1·0 mm

Maximum rain intensity.—If meso-scale systems are to be used in forecasting over the British Isles they must be detected before they have progressed very far into what is a relatively sparse network of observations over a small area and some assistance is obtained by plotting the progress of lines or centres of maximum rain intensity.

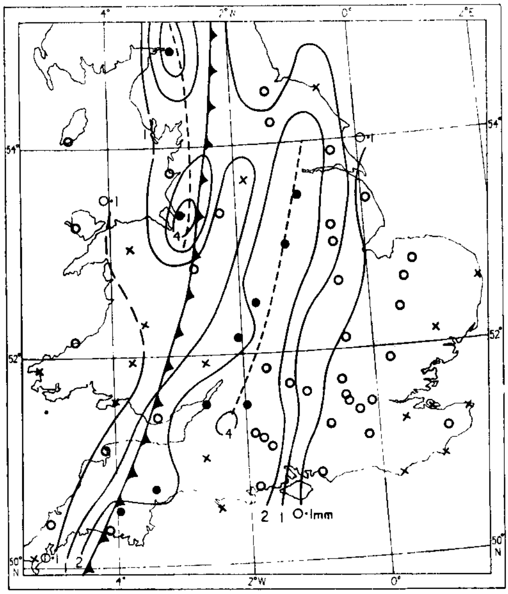

FIGURE 1(*a*)—ISOPLETHS OF HOURLY RAINFALL 1100–1200 GMT, 24 SEPTEMBER 1963

An isopleth is represented by a dashed line when the drawing is very uncertain. The frontal position is given for 1200 GMT.

– – – – 1200 GMT position of line of maximum value

o rainfall report; ● rainfall report maximum; × present weather observation only

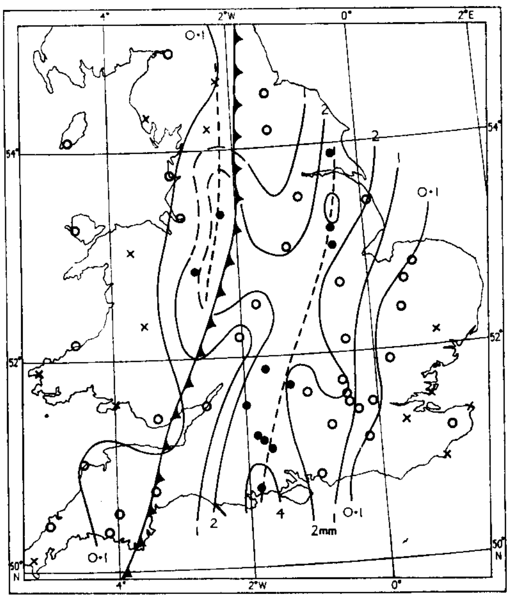

FIGURE 1(*b*)—ISOPLETHS OF HOURLY RAINFALL 1200–1300 GMT, 24 SEPTEMBER 1963

An isopleth is represented by a dashed line when the drawing is very uncertain. The frontal position is given for 1300 GMT.

– – – – 1300 GMT position of line of maximum value

o rainfall report; ● rainfall report maximum; × present weather observation only

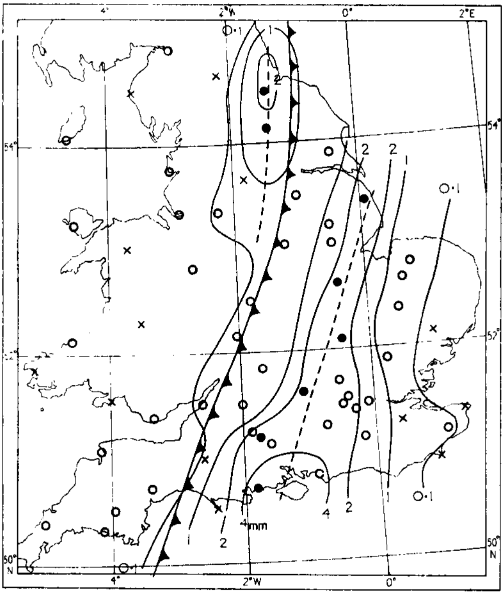

FIGURE 1(*c*)—ISOPLETHS OF HOURLY RAINFALL 1300–1400 GMT, 24 SEPTEMBER 1963

An isopleth is represented by a dashed line when the drawing is very uncertain. The frontal position is given for 1400 GMT.

– – – – 1400 GMT position of line of maximum value

o rainfall report; ● rainfall report maximum; × present weather observation only

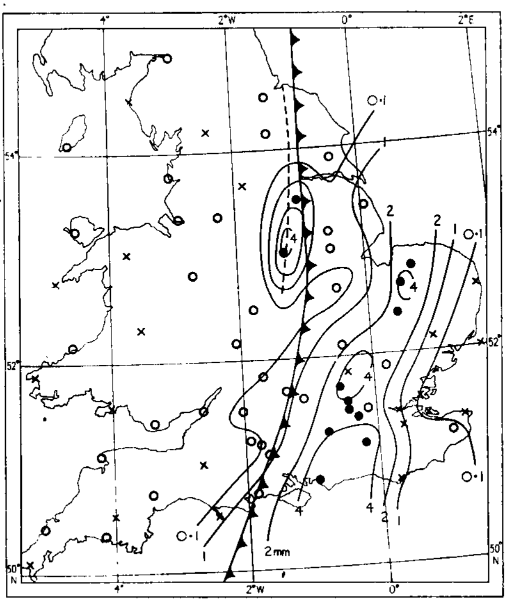

FIGURE 1(*d*)—ISOPLETHS OF HOURLY RAINFALL 1400–1500 GMT, 24 SEPTEMBER 1963

An isopleth is represented by a dashed line when the drawing is very uncertain. The frontal position is given for 1500 GMT.

– – – – 1500 GMT position of line of maximum value

o rainfall report; ● rainfall report maximum; × present weather observation only

If a narrow band or small area of rain moves steadily across the country, the rain intensities which occur may vary considerably from station to station and so may the total rain and the duration of the rain, especially if some stations are exposed at a high altitude and others are in a rain shadow. The isopleths of hourly amounts will move irregularly : the higher-valued isopleths will tend to jump ahead to the higher-level stations, lingering there when the main belt has passed, but completely by-passing stations in the rain-shadow. Likewise isochrones of the time of onset of rain will move in an irregular way.

However, unless the dynamical system causing the rain is very greatly affected by the topography it is feasible to expect that the time at which the maximum rain intensity is experienced at each station should progress at the same steady speed as the dynamical system itself.

Indeed an analysis of time cross-sections of rainfall shows that it is not unusual for stations which are within a few hundred miles of each other to experience similar sequences of intensity peaks even though the exposures and the total rain catches are quite different at the stations. The isochrones of maximum intensity often move regularly even when the intensities themselves are rather variable. When more than one peak occurs the time lapse between peaks is often the same at different stations.

Isochrones of maximum intensity are useful not only for identifying and tracking meso-scale features but also for identifying two parts of what is effectively the same meso-scale feature, the portion between them having been suppressed by topography.

It is unfortunate that it is not possible to decide whether or not a particular hourly value is a maximum until the next report is available but it has been found practicable to apply this principle of maximum intensity to hourly rainfall charts by underlining the maximum value at a station in some distinctive colour and then examining two or three successive charts to see whether the marked values form a consistent sequence.

Complications occur in the marking of the charts and in Table II a scheme is suggested.

A certain amount of latitude of timing must be allowed when following the maximum from chart to chart since random irregularities may displace the maximum from one hour to another. If the reported hourly maximum value is not much larger than the previous value it is likely that the real maximum rain intensity occurred in the first half of the hour of accumulation, whereas the real maximum would probably be in the second half of the hour if the reported maximum is not much larger than the following value. The markings in the table will assist in marking a line of maximum values on the chart.

Thus $\underline{XX}$ or $\underline{XX}$ indicates a maximum near the mid-point of the hour

$\underline{XX_E}$ or $\underline{XX_E}$ indicates a maximum in the first half of the hour

$\underline{XX_L}$ or $\underline{XX_L}$ indicates a maximum in the second half of the hour.

If the rain bands are present near a front they are most likely to be orientated along the front and moving at the same speed. On the other hand

TABLE II—SCHEME FOR MARKING MAXIMUM RAIN VALUES

$\underline{XX}$	Hourly maximum : at least 10 per cent greater than the previous or the following value Underline plotted value (XX) with full line to indicate maximum near the mid-point of the hour
$\underline{XX_E}$	Hourly maximum : but less than 10 per cent greater than the previous value Underline with full line and add subscript E to indicate maximum in first half of the hour
$\underline{XX_L}$	Hourly maximum : but less than 10 per cent greater than the following value Underline with full line and add subscript L to indicate maximum in second half of the hour
$\underset{---}{XX}$	Hourly maximum : but less than 10 per cent greater than both the previous and the following value Underline with dashed line to indicate less definite maximum near mid-point of the hour
$\underset{---}{XX_E}$	Value greater than the following value but equal to the previous value Underline with dashed line and add subscript E to indicate maximum in first half of the hour
$\underset{---}{XX_L}$	Value greater than the previous value but equal to the following value Underline with dashed line and add subscript L to indicate maximum in second half of the hour

it is difficult to forecast whether areas which are more circular in form will progress with the front or move in a direction closer to that of the thermal wind, and for the present the procedure must be one of detecting the areas as soon as possible and extrapolating the movement observed during the past few hours.

In warm sectors the quantitative observations define quite well the stripes of rain that form downwind of gaps between high ground, e.g. eastwards from the Bristol Channel.

Using the analysis of maximum intensity it has been found that occasionally tongues of rain extending eastwards or south-eastwards around the north and south flanks of the Welsh mountains ahead of a warm front are apparently two parts of the same dynamical system, namely a line of maximum intensity orientated north–south, the centre part of which has been suppressed in the lee of the mountains. The link is indicated by small amounts of rain falling at stations such as Ross-on-Wye and Birmingham Airport at about the time that a line joining the time maxima to the north and to the south crossed these stations. The two rain areas sometimes join up again further to the east well away from the orographic features. The occasion of 2 September 1948 quoted by Wallington is apparently of this type, although on this occasion the rain was completely suppressed in an area just to the lee of the Welsh mountains.

Example of 24 September 1963.—The hourly charts for 1200 GMT to 1500 GMT, 24 September 1963 are shown in Figure 1 (*a*) to (*d*). The cold front was well defined by a strong wind shift across it. The main belt of rain ahead of the front was well defined by the isopleths and by the line of maximum values except near the south coast. The rain associated with the cold front itself was not at all well defined by the 'present weather' observations, and the closed isopleths moved erratically on the rainfall charts but every station north of Shawbury had a maximum about the time of passing of the front (including Blackpool Airport at 1100 GMT) and its separation from the previous rain is easy to see on these charts. In the southern part of the area it is clear that the cold front is not bringing any intensification of the rain.

Conclusion.—Hourly rainfall observations may eventually be used to define meso-scale rain features and to forecast their future movement and development. The requisite forecasting technique has not yet been developed, but meanwhile the plotted observations can be used for estimating the intensity of rain systems and an extrapolation method could be used for forecasting a few hours ahead. Forecasters would find a study of hourly rainfall charts of considerable interest and a great help towards an understanding of the apparently anomalous distributions of longer-period rain totals.

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1. WALLINGTON, C. E.; Meso-scale patterns of frontal rainfall and cloud. *Weather, London*, **18**, 1963, p. 171.

551.507.362.2:551.509.311:77

SATELLITE PICTURES OF AN OLD OCCLUDED DEPRESSION AND THEIR USEFULNESS IN ANALYSIS AND FORECASTING

By I. J. W. POTHECARY and R. A. S. RATCLIFFE

Summary.—Satellite photographs of an old occluded depression are described to show their use in the analysis of the structure and movement of the depression and its associated fronts. The position of the core of the associated jet stream can also be deduced, as well as the presence of sea-ice.

The satellite photographs, received from the automatic picture transmission (APT) facility on ESSA II, are shown to have played an important part in the integration of the observed data and their immediate availability was a major factor in the formulation of a correct forecast.

Introduction.—Satellite television pictures have been received daily in the Central Forecasting Office, Bracknell, since the beginning of March 1966 from the automatic picture transmission (APT) facility on ESSA II, the second satellite of the United States operational satellite system.

Experience in the interpretation and use of directly received APT satellite pictures is accumulating and many occasions have occurred when satellite cloud pictures have made significant contributions to analysis and have been an important aid in the preparation of forecasts. Interpretation has also been successfully extended to the location of jet streams and the identification of the nature and limits of sea-ice in northern waters. Information on snow cover has also been obtained.

A case-study of an old occluded depression is presented as an illustration of the use of observational data available in APT satellite photographs.

APT satellite parameters.—Automatic transmission of satellite television pictures is currently being made from ESSA II, the second of the TIROS operational satellites (TOS),[1] launched by the United States on 28 February 1966. The satellite is in a slightly elliptical near-polar orbit with an apogee of 1413 km and a perigee of 1353 km. The period of the orbit is 113·4 minutes and successive crossings of the equator are 28·4 degrees further west, effectively keeping pace with the sun and passing over the same area on the earth's surface twice daily at fixed local times, once near midday when the satellite is moving from slightly east of north to slightly west of south and once near midnight when the satellite is completing its orbit over the dark side of the earth.[2]

The interval between successive APT pictures is 352 seconds and the reception of each picture is completed within 184 seconds of the time the picture is taken. Each picture covers a square with sides of about 1500 n. miles. The overlap between successive pictures on the same orbit is about 500 n. miles and the overlap between pictures from successive orbits is about 350 n. miles in the latitude of the British Isles. The resolution at the centre of each APT picture is about 2 n. miles, reducing to about 4 n. miles at the edges.

The satellite must be above the horizon for APT pictures to be received, but even with this limitation it is possible to receive pictures at Bracknell covering an area including the North Pole, central Siberia, the Black Sea, the eastern Mediterranean, North Africa, the Atlantic from the Canary Islands to Nova Scotia, Labrador, Baffin Island and the Davis Strait. The coverage varies with satellite altitude and with the quality of reception for low aerial elevations.

APT analysis for 0950 and 1143 GMT on 5 May 1966.—

Cloud organization.—The dominant feature in the organization of the cloud shown in the APT pictures for 0950 and 1143 GMT on 5 May 1966 (Plates I and II) is the vortex centred at about 56°N 16°W. This vortex showed no detectable movement, within the accuracy of location, over the 113 minutes between the pictures. The cloud in the lines forming the vortex was assumed to be largely convective, particularly in the southern part of the vortex where granulated structure is more apparent. It was also assumed that the lines of cloud were stretched out along the shear vector, indicating the thermal pattern in the layer containing the cloud rather than the actual flow.[3] As the depression was an old occluded system the position of the vortex centre was taken as a reasonable approximation to the surface position of the depression centre.[4,7]

The APT picture, reproduced in Plate I and given in nephanalysis form in Figure 1, shows a broad and continuous band of cloud covering southern Scandinavia and spiralling in towards the centre of the vortex. The high reflectivity and intense whiteness of the cloud over most of the band confirmed that this was active and well-organized frontal cloud reaching to high levels in the troposphere. The sharp change to clear dry air along the western boundary of the cloud system, with evidence that dry air had already penetrated to the centre of the vortex, showed that this was, as indicated in the surface analysis for 1200 GMT on 5 May 1966 (Figure 2), the main occluded front of the depression.

The granulated structure of the cloud over a large area around the depression away from the vicinity of the occlusion showed the presence of convective cloud — evidence that the cold air in the lower troposphere was

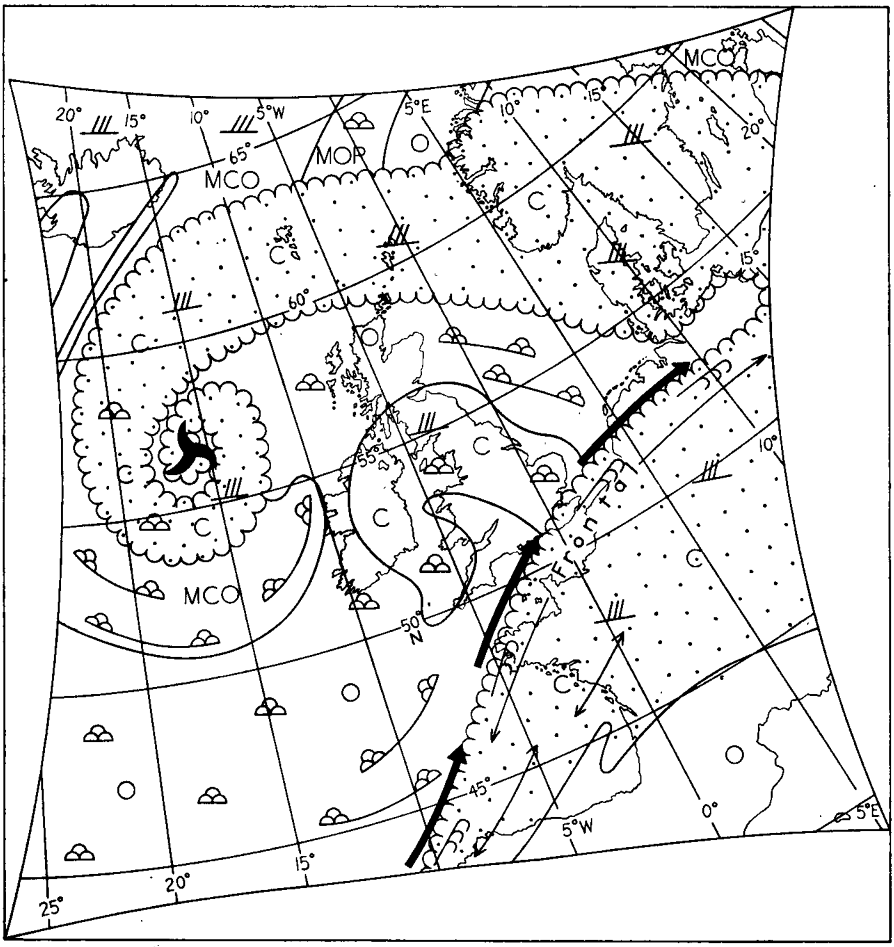

FIGURE I — NEPHANALYSIS BASED ON ESSA II APT SATELLITE TELEVISION PICTURE AT 0950 GMT ON 5 MAY 1966

	Cirriform cloud		Vortex centre
	Cumuliform cloud		Boundary of major cloud system
	Stratiform Cloud		Boundary of unorganized cloud mass
	Cloud striations		Jet stream

O 20 per cent coverage

MOP 20–50 per cent coverage

MCO 50–80 per cent coverage

C 80 per cent coverage

Stippling represents cloud organization considered to be synoptically significant

To face page 334

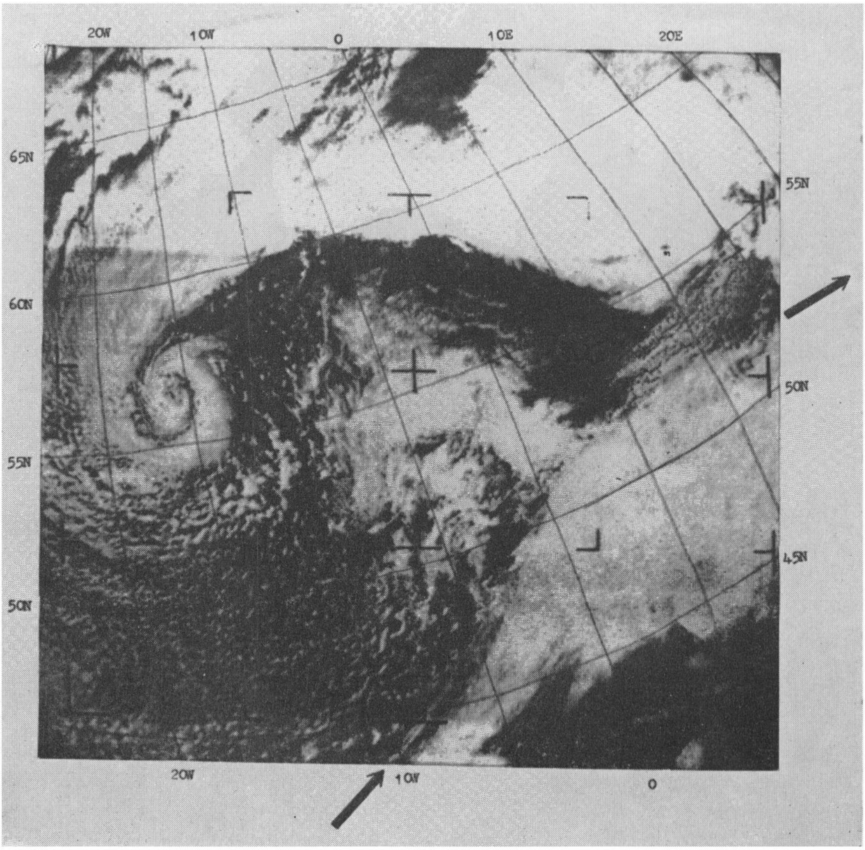

PLATE I—ESSA II APT SATELLITE TELEVISION PICTURE—CENTRED OVER SOUTHERN SCOTLAND AT 0950 GMT ON 5 MAY 1966 ON ORBIT 835 AT A HEIGHT OF 1353 KM (The arrows locate the assumed position of the core of a jet stream).

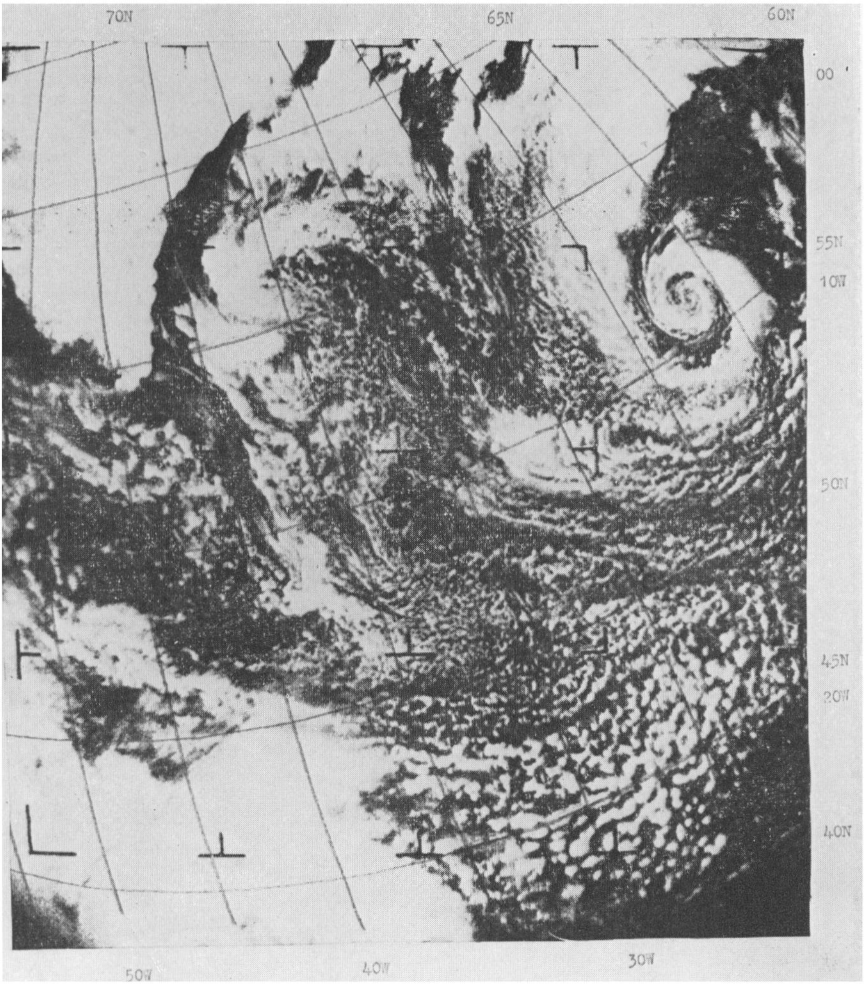

PLATE II—ESSA II APT SATELLITE TELEVISION PICTURE—CENTRED OVER MID-ATLANTIC (56°N 32½°W) AT 1143 GMT ON 5 MAY 1966 ON ORBIT 836 AT A HEIGHT OF 1353 KM.

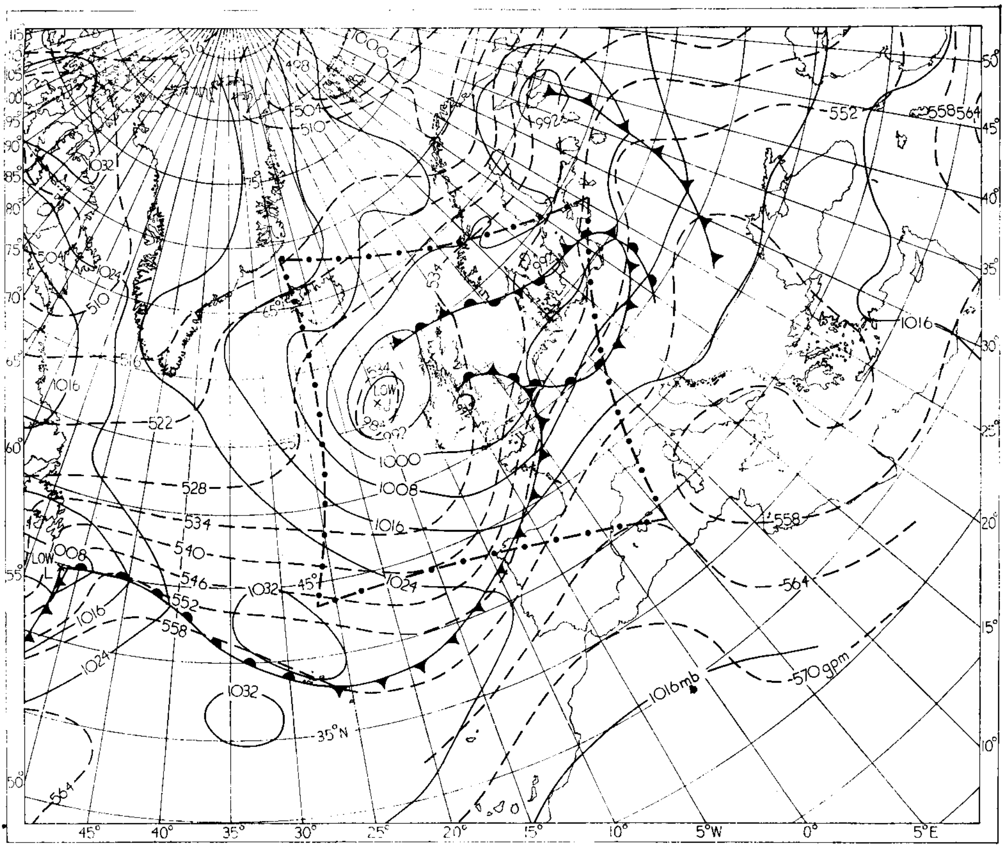

FIGURE 2 — SURFACE ANALYSIS AND 1000–500 MB THICKNESS FOR 1200 GMT ON 5 MAY 1966

·–·–· Boundary of area covered by satellite photograph (Plate I)

unstable for sea surface temperatures. As the maximum resolution does not go below about 2 n. miles the granulations represent clumps of convective cloud rather than individual cumulus or cumulonimbus.

The smooth boundary to the dense white reflection from Greenland (top left of Plate II) shows the presence of sea-ice in coastal waters. Later in the year, following the melting of the ice, the indented nature of the Greenland coast was clearly shown. The same dense whiteness is also typical of reflection from the snow-covered Alps which are frequently seen on APT pictures received at Bracknell and are usually clearly recognizable by their 'fern-like' appearance due to the snow-free valleys.

The surface analysis (Figure 2) shows a short occlusion drawn over the British Isles from a shallow depression over the Irish Sea to a wave tip near East Anglia. The wave occurred on the cold front running through northern Germany, the Low Countries and northern France. The occlusion had been followed through ship observations over the eastern Atlantic but the satellite picture (Plate I) showed that the organization which should have been present if the occlusion had retained its structure was lacking. On the original facsimile copy it can be seen that the cloud over most of the British Isles had a granulated structure, randomly arranged. This detailed structure is partly obscured by the increased contrast in the photographic reproduction. The random arrangement of the convection suggests that the occlusion had degenerated into cloud more typical of the increased convection in a broad trough in the circulation of the depression rather than an organized frontal system.

Jet-stream identification.—The satellite photograph (Plate I) shows a mass of cloud covering the Bay of Biscay, northern France and the Low Countries. The cloud was associated with the cold front shown in the surface analysis (Figure 2), and the high reflectivity shown in the picture suggests that the cloud was dense and extended to high levels. The northern edge of the cloud sheet is marked by long thin streaks of cloud stretching over a considerable distance, through about 44°N 10°W and extending northeastwards over the English Channel before curving eastwards across Germany. The striations, which have a lower reflectivity than other cloud systems in the picture, appear to run over the lower convective cloud suggesting that they were features of the cloud cover at high levels and were probably thick cirrus.[5]

The northern limit of the striations, with clear air at high levels to the north, was assumed to give the position of the core of the jet stream associated with the occluded depression.[6] The assumed position of the jet is marked by arrows on the southern and eastern edges of the satellite photograph (Plate I) and is shown in the nephanalysis prepared from the picture (Figure 1).

The satellite picture should be compared with the 300 mb chart for 1200 GMT on 5 May 1966 (Figure 3). The isotach maximum, interpolated over the Atlantic through a very sparse network of upper air observations, is carried round the upper trough to the north-westerly jet stream over mid-Atlantic in line with the operational analyses. The core of the jet located from the satellite evidence coincides with the isotach maximum eastwards from about 10°W but west of that longitude the striations continue south-westwards and can be followed on the next satellite picture in the same orbit to about 40°N 20°W. If the interpretation of the striations as a locator for the jet core is correct then the assumed continuity of the jet around the upper trough was not present and two separate jet streams existed. The sparseness of the upper air network over the Atlantic prevents the confirmation of this configuration of the jet but the coincidence of the isotach maximum and the cloud streaks through the close upper air network in western Europe suggests that the location of a jet may be derived from satellite evidence alone in regions where insufficient upper air data is available for detailed analysis.

Synoptic situation on 5 May 1966.—On 4 May a fairly deep depression had moved quickly north-eastwards towards Scotland over the Atlantic. It was expected that this depression would cross Scotland to be near the Shetland Islands by midday on 5 May. Instead it slowed down over the eastern Atlantic and by the morning of 5 May it was slow-moving west of the Hebrides. Another shallow depression of complex origin, the fronts of which were at all times embedded in the strong south-westerly upper flow on the south side of the main low, made steady progress north-eastwards until by midday on 5 May this depression was over the Irish Sea as a weak centre (Figure 2). The associated 300 mb analysis for 1200 GMT on 5 May is shown in Figure 3.

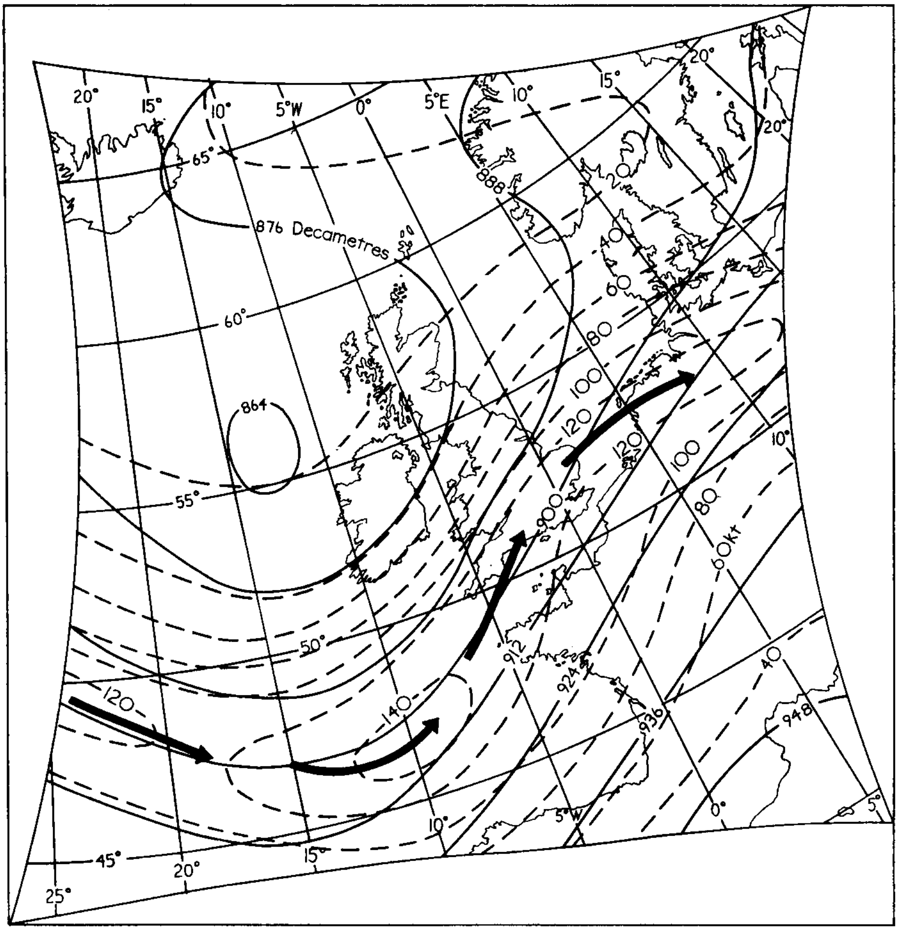

FIGURE 3—300 MB CONTOUR AND ISOTACH CHART FOR 1200 GMT ON MAY 5 1966, COVERING THE AREA SHOWN IN PLATE I

———— Contours at 12-decametre intervals

— — — Isotachs at 20-kt intervals

The jet stream is indicated by a series of bold arrows

Synoptic systems on the other side of the Atlantic had an important bearing on the compilation of 24-hour surface prognostic charts on 5 May and it is necessary to refer to them if the situation is to be fully understood. The main feature was the very intense cold trough over Hudson Bay with a smaller trough near Nova Scotia. This latter trough, although much smaller than the Hudson Bay trough, contained some quite cold air and was associated with a shallow depression which was showing signs of deepening by midday on 5 May. The Hudson Bay trough was too large and well established to move or disappear quickly and, with the two upper troughs separated only by about 30 degrees of longitude, the expected development was that the forward trough and its associated depression (Low L in Figure 2) would move quickly eastwards over the Atlantic, increasing the trough separation and allowing a limited deepening of the centre. This evolution of the pattern was supported by computed forecasts. The eastward movement of the depression was likely to be fast enough for the ridge ahead of it to be approaching western districts of Britain during 5 May.

The use of APT in forecasting on 5 May 1966.—It was evident that the position of the cloud vortex shown on the APT pictures was to the south of the surface centre of the depression as analysed on the synoptic charts. This would have been expected if the depression had been a baroclinic system, but with an old occluded depression it was more likely that the cloud vortex and the position of the surface centre of the depression would show a much closer relation than appeared to be the case.[4,7] The APT pictures prompted a fresh look at previous charts, particularly that for 0600 GMT on 5 May on which late ship observations were available. As a result of re-analysis it appeared that the main depression had been moving only slowly for some time. At this stage an early ship report on the 1200 GMT chart gave a pressure of 980 mb and a westerly wind at a position just south of the centre of the vortex shown on the APT pictures. The available synoptic data, integrated into the analysis with the assistance of the APT pictures, suggested that the surface centre of the depression was almost certainly at about 56½°N 15°W at 1200 GMT on 5 May. Drawing the depression in this position resulted in a very tight gradient on the south-west side. With the whole system then regarded as a barotropic vortex the future movement was likely to be controlled more by the strongest flow than by any other factor. No movement could be detected within the limits of accuracy of location over the interval between the two APT pictures suggesting that at this stage at least the depression was moving only very slowly. The surface prognostic chart for 1200 GMT on 6 May was therefore constructed on the assumption that the depression would move slowly south-east for the first 12 hours as the depression near Nova Scotia developed. It was expected that the south-eastward movement of the depression J would then tighten the gradients on the southern side as the gradients to the west relaxed, causing the centre to turn left and probably accelerate across northern England to a position over the North Sea by the end of the 24 hours. As a barotropic vortex it would almost certainly fill but at 1200 GMT on 5 May its depth was about 976 mb and such a strong vortex was considered likely to stay fairly deep, at least for the first 24 hours. The surface pressure of the centre was therefore forecast to be 989 mb in 24 hours time. In fact by then it had filled to 995 mb and the depression did not turn east as much as was expected during the second half of the forecast period, probably because the oncoming Atlantic ridge maintained the gradient on its western flank. The errors in the forecasts issued on the prognostic chart were minor compared to the errors which would have been made had earlier forecasts of a continued north-eastwards movement of the centre been maintained.

Photograph by D. Ford

PLATE III—RIME ICE ACCRETION ON THE SUNSHINE RECORDER PILLAR AT THE MINISTRY OF AVIATION RADIO STATION, LOWTHER HILL, LANARKSHIRE ON 14 FEBRUARY, 1966

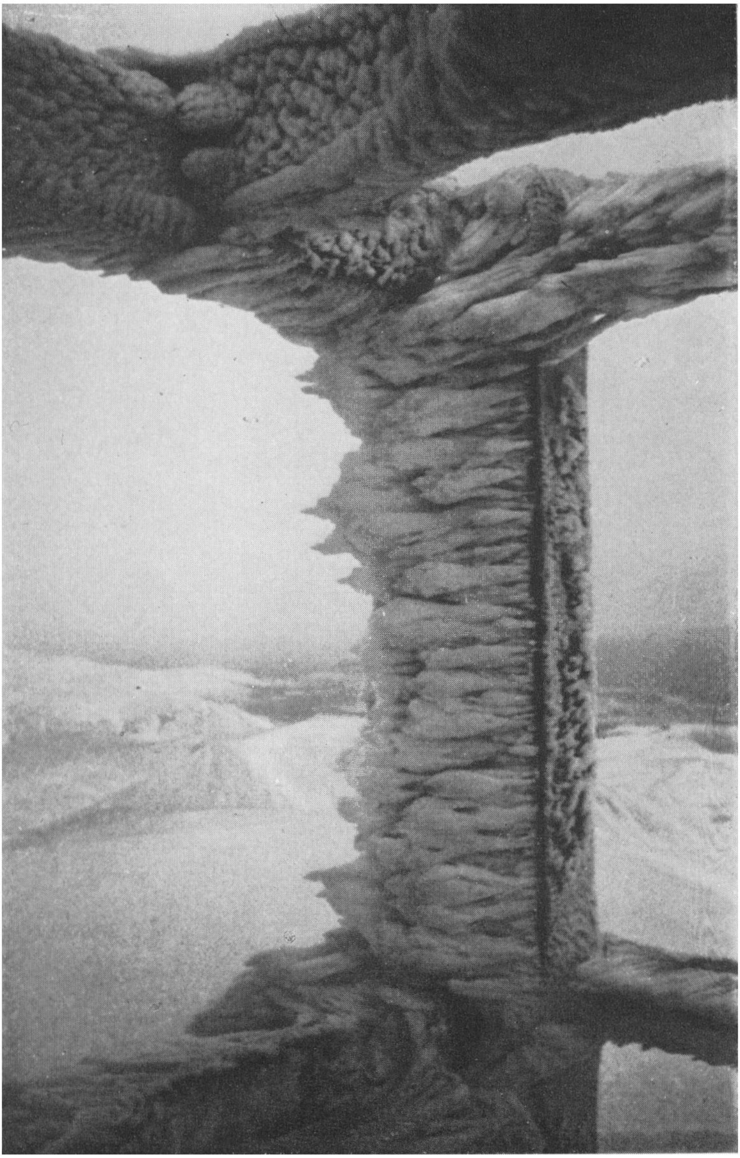

PLATE IV—RIME ICE ON A WOODEN AERIAL MAST AT THE MINISTRY OF AVIATION RADIO STATION, LOWTHER HILL, LANARKSHIRE, ON A DAY IN NOVEMBER 1962

The timbers are 4 inches square, so the rime is about 12 inches thick. The wind was from the north ; the discoloration of the ice is due to the industrial haze from Clydeside.

Conclusions.—The accumulation of experience in the interpretation and use of APT satellite pictures in operational forecasting is providing some convincing evidence of the importance of this new source of observational data and giving new insights into the organization of the cloud, and hence the weather-producing systems of a wide variety of synoptic features. Experience has already shown that it is the exception if no new information can be deduced about the synoptic analysis from a careful study of APT pictures, including information which can be used, if the appropriate associated upper cloud structure is present, to locate jet streams.

As an example of the operational use of satellite data the structure of an Atlantic depression and its movement were deduced several hours before the surface and upper air data were available from the area, making possible a substantially correct assessment of its future movement and intensity. APT pictures have shown their value on many other occasions as a substantial aid in operational forecasting, both in their use in integrating other observed data and in their immediate availability.

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A NOTE ON THE LARGE-SCALE FEATURES OF THE 1962/63 WINTER

By R. MURRAY

Summary.—The circulations at 500 mb and 1000 mb over the northern hemisphere during the exceptional winter of 1962/63 are briefly described and compared with the long-period average winter circulations. Charts are also given for January 1963 illustrating the main departures from normal, and special reference is made to the features near the British Isles. Temperature and rainfall anomalies for the winter are shown as well as the main anomalous features in January 1963 of the sea surface temperature, snow cover and sea-ice. No convincing explanation is put forward for the large-scale circulation developments though anomalous patterns of sea surface temperature appear to have characteristics which harmonize with large-scale blocking patterns near western Europe.

Introduction.—Other winters have had prolonged spells of very cold weather (e.g. 1878/79, 1890/91, 1894/95, 1916/17, 1939/40, 1946/47), but in the past 100 years only the winters of 1878/79 and 1946/47 approached the severity of 1962/63 over Britain as a whole. Moreover, the 1962/63 winter was the coldest in central England since 1739/40. Notable cold spells over Britain during the third week of November 1962 and early in December 1962 were almost premonitory, but the persistently severe weather finally set in on 22/23 December 1962 and lasted in most places until 4/5 March 1963 when Atlantic air spread north-eastwards and brought a general thaw.

The severe winter over the British Isles was one localized aspect of a winter which was in fact exceptional on a far larger scale, and it is worth discussing some of the unusual features of the hemispherical circulation.

Broad-scale circulation.—The general circulation in the middle troposphere (e.g. at 500 mb[1]) in winter is predominantly westerly, but the mean flow has troughs over eastern North America (about 80°W at 50°N) and near the east coast of Asia (about 140–145°E at 50°N) with a much weaker third trough over eastern Europe (about 45°E at 50°N). The troughs at 500 mb are generally cold and the ridges are warm with the result that the average pattern of 1000–500 mb thickness is broadly similar to the average 500 mb flow. The sea-level counterpart of the upper pattern is well known ; the main features or 'centres of action' are the low-pressure areas to the south-west of Iceland (the 'Icelandic low') and near the Aleutians (the 'Aleutian low'), the subtropical anticyclones in the Atlantic (the 'Azores high') and in the Pacific (the 'Pacific high') and an extensive continental area of high pressure centred over Mongolia.

It is worth recalling the main differences between the winter circulation of 1962/63 and the normal, long-period average, picture. The European upper trough was much more intense than usual and generally west of its normal position ; the American trough was also more pronounced than usual ; the third major trough was relatively weak in high latitudes over eastern Asia, but broad-based from southern Japan to mid-Pacific. The corresponding surface pressure patterns were equally abnormal ; in particular the 'Icelandic low' was virtually non-existent for much of the winter and pressure was unusually high in the Iceland region.

The characteristic feature of this winter was the abnormal degree and frequency of blocking, particularly over the North Atlantic and western Europe but also in the Pacific sector. Blocking was greatest in January as may be inferred from the highly anomalous mean monthly charts for January 1963 shown in Figure 1 for surface pressure and in Figure 2 for 500 mb contours. Particularly noteworthy in Figure 2 are the great amplitudes of the troughs and ridges, the three-trough system and the twin vortices (one north of Hudson Bay and the other near the North Pole). The upper tropospheric and lower stratospheric circulations in January 1963 were broadly similar to the 500 mb flow.

The abnormality of the winter circulation in different longitudes of the northern hemisphere is indicated in greater detail in Figure 3(*a*) (500 mb) and Figure 3(*b*) (1000 mb). These figures depict the anomalies of mean geostrophic west-wind between latitudes 40° and 60°N on a 5-day time-scale from early December 1962 to the end of March 1963. The outstanding feature is the stability of the patterns of anomalously weak westerly flow on very large space- and time-scales. It is also striking that the markedly subnormal westerly flow over the Atlantic and western Europe set in rather suddenly after 20 December 1962, persisted into February 1963 and then gradually changed to a slightly enhanced westerly circulation.

The negative anomaly of westerly flow shown in Figures 3(*a*) and 3(*b*) was naturally associated with many other unusual features of the circulation on a regional basis, such as highly abnormal southerly and northerly flow according to the locations of the major long waves, as well as anomalously strong jet streams in certain sectors in very high and very low latitudes.

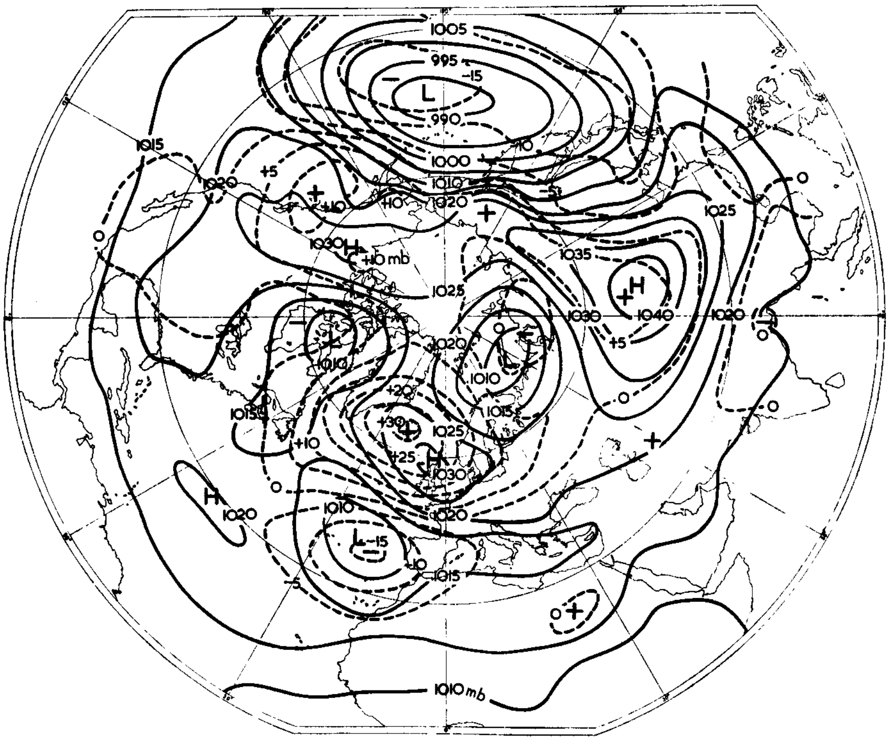


FIGURE I—MONTHLY MEAN SEA-LEVEL PRESSURE AND ANOMALIES FOR JANUARY 1963

——— isobars at intervals of 5 mb

- - - anomaly isopleths at intervals of 5 mb

Temperature and rainfall anomalies.—The anomalies of air temperature and rainfall in the winter are shown in Figures 4 and 5, where the conventional three winter months are used.

Figure 4 shows the main anomalously cold centres over the Russian Arctic, over central Europe and over America just south of the Great Lakes, as well as equally notable centres of unusually warm air over the Davis Strait and over north-east Siberia. Each of the three winter months had broadly similar large-scale temperature patterns, but the monthly anomalies were greatest in January 1963 (e.g. −10 degC in Poland and +11 degC near the Bering Strait).

The broad-scale rainfall distribution is shown in Figure 5. The winter was wetter than average along a characteristic depression track from the Azores to south-eastern Europe (over 200 per cent of normal rainfall at many places), over eastern Europe on the forward side of the upper cold trough, near eastern coastal areas of North America on the forward side of the American cold trough and also over Alaska and western Canada where southerly advection of moist Pacific air was unusually pronounced. Drier than usual weather occurred over a large area from Iceland to north-western Europe where anticyclonic blocking was the dominant circulation feature.

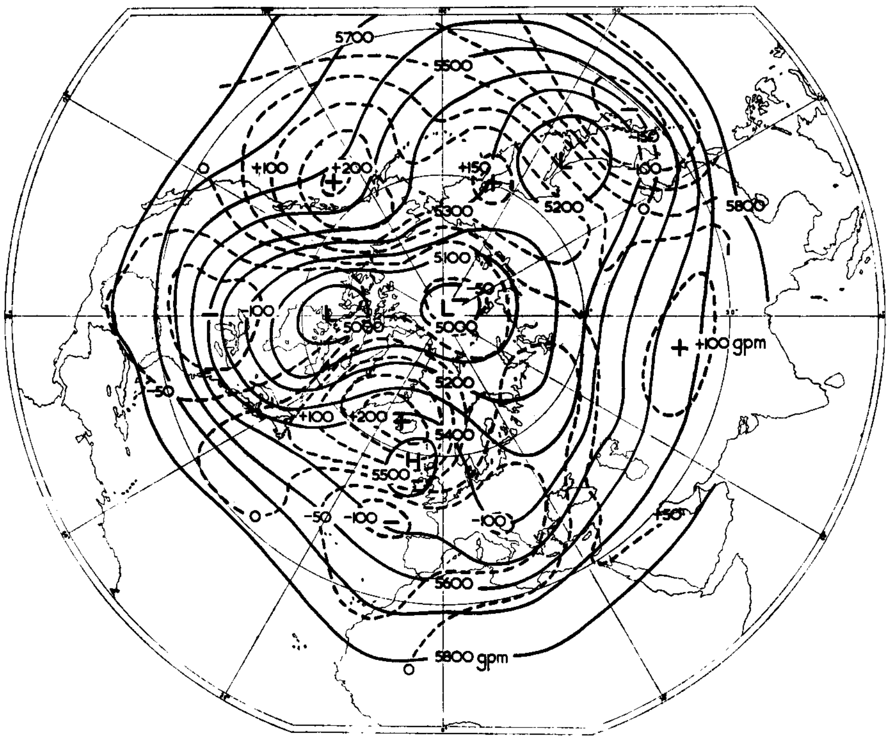


FIGURE 2—MONTHLY MEAN 500 MB CONTOURS AND ANOMALIES FOR JANUARY 1963

——— contours at intervals of 100 geopotential metres

- - - - anomaly isopleths at intervals of 50 geopotential metres

The underlying surface.—Figure 6 summarizes the main anomalous features of sea surface temperature, snow cover and polar ice in January 1963 at the height of the severe winter.

Namias[3] has pointed out that the surface waters of the North Pacific were unusually warm throughout the winter and in the preceding autumn and summer. For example in September 1962 positive anomalies exceeding 1 degC covered much of the North Pacific with a peak of +4 degC at about 42°N 173°W. In January 1963 the peak anomalies were not quite as large as in the preceding months or as in February 1963, but positive anomalies extensively exceeded 1 degC, and the broad-scale sea temperature pattern did not change much.

The North Atlantic sea surface was persistently warmer than usual in high latitudes from near southern Greenland to the southern Norwegian Sea. Early in the winter this anomalously warm area was weakly linked over the eastern Atlantic to an extensive warm band which stretched across the Atlantic in lower middle latitudes. With the onset of the severe weather, the sea temperatures soon became abnormally cold around the British Isles (Figure 6) and ice developed in the North Sea along the coast. Meanwhile an anomalously cold area in mid-Atlantic near ocean weather station 'C'

(52°45′N, 35°30′W) in December 1962 expanded southwards in January 1963 and linked up with an area of slightly cooler than average water already in existence in December in the subtropics. By the end of February 1963 negative anomalies were observed in a band across middle latitudes in the Atlantic and around the British Isles. The limits of snow cover late in January 1963 are indicated in Figure 6. Moreover, snow cover was more general than it usually is over western Europe and the British Isles from late December 1962

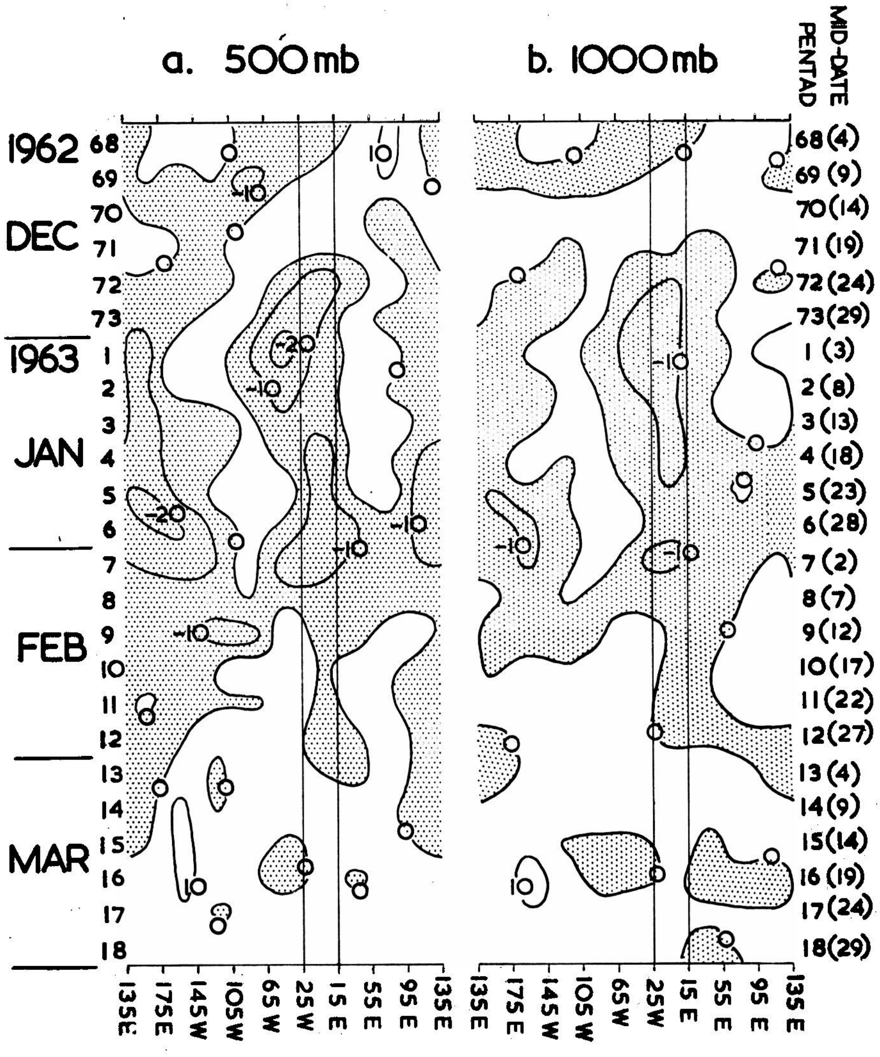


FIGURE 3—ANOMALIES OF 5-DAY MEAN WESTERLY GEOSTROPHIC WIND BETWEEN 40°N AND 60°N FOR NINE SECTORS OF THE NORTHERN HEMISPHERE FROM PENTAD 68 (2–6 DECEMBER) 1962 TO PENTAD 18 (27–31 MARCH) 1963 AT (*a*) 500 MB AND (*b*) 1000 MB

Vertical lines are drawn at 25°W and 15°E to indicate the sector centred over the British Isles to early March 1963. Throughout the severe winter the area of extensive snow and frozen ground over Europe persisted except during one or two temporary periods of slow thawing near the Atlantic seaboard, chiefly over France, when Atlantic air encroached upon the mainland over limited sectors.

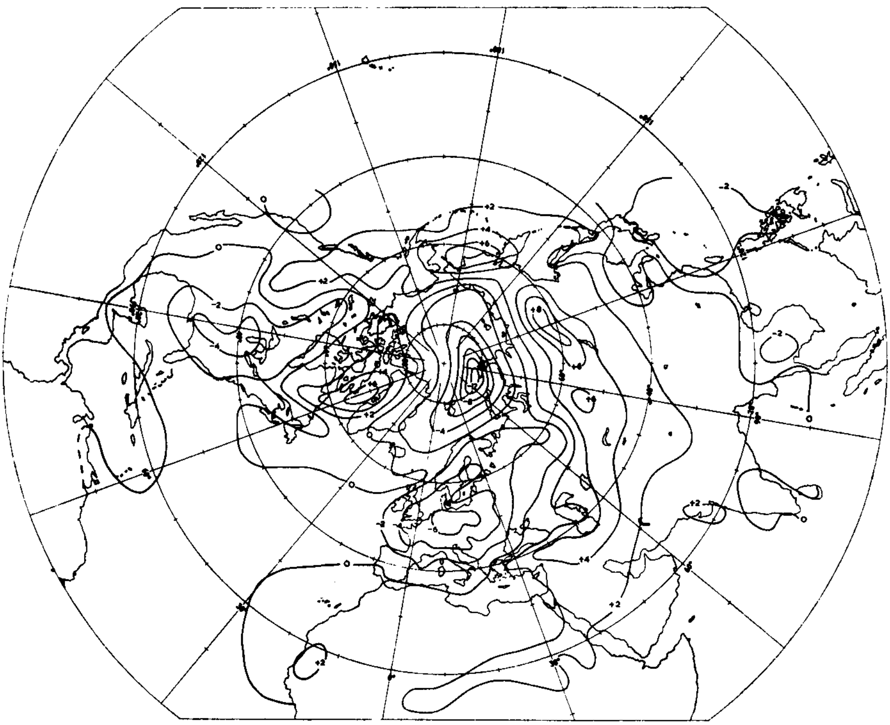


FIGURE 4—SURFACE TEMPERATURE ANOMALIES FOR DECEMBER 1962 TO FEBRUARY 1963

——— anomaly isopleths at intervals of 2 degC

Over America, the boundary of significant snow cover was south of the average position intermittently in December 1962 and more generally so later in the winter. Examination of synoptic charts suggests that there was less snow than usual over south-west Asia but more than usual over eastern Asia ; certainly exceptionally heavy snowfalls occurred over Japan, especially in January 1963.[3]

As regards the polar ice it need only be mentioned that it was much more extensive than usual off east Greenland and in the Barents Sea in the winter, but the area of the anomaly pattern for excess amounts of ice was on a small scale compared with other surface anomaly patterns.

Discussion.—Namias[2] has suggested that the persistently warm waters of the central and eastern parts of the North Pacific were the primary cause of the anomalous circulation developments, but this is not yet proven. However, certain repetitive synoptic developments in the North Pacific were not inconsistent with the existence of an unusually persistent energy source in the abnormally warm surface of the ocean.

In November 1962 the upper flow, unlike later patterns, was mainly zonal and synoptic disturbances generally progressed eastwards on a track in high latitudes to the north of the anomalously warm waters. Early in December the upper westerlies shifted to lower latitudes ; the depressions then travelled

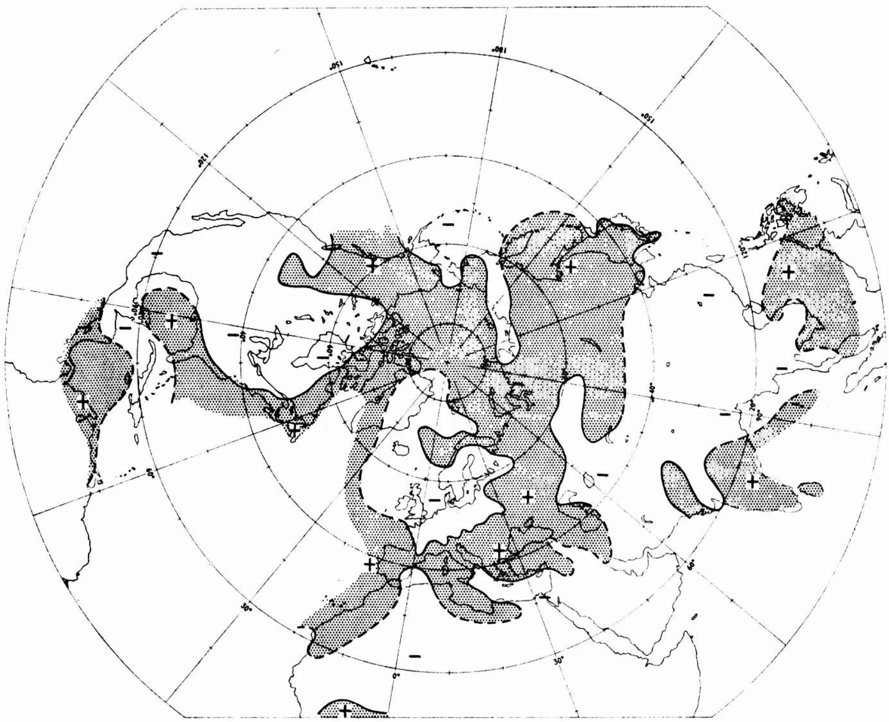


FIGURE 5—AREAS WITH RAINFALL IN THE 1962/63 WINTER BELOW (NEGATIVE) AND ABOVE (POSITIVE) THE SEASONAL AVERAGE

+ above normal rainfall
- below normal rainfall
—— isopleth of 100 per cent normal rainfall (dashed in regions of scanty evidence)
Shading is used to indicate areas with above normal rainfall

eastward, deepened considerably near the warm pool of surface water, and turned sharply in a northerly direction between longitude 170°W and 140°W. A strong upper ridge then developed farther east over the eastern Pacific and western America ; immediately downstream the American cold trough extended southwards, whilst farther downstream other oscillations in the upper air pattern were set up. For the rest of December, and indeed throughout most of the winter, cyclonic activity was vigorous near the unusually warm pool of water in the North Pacific and depressions generally turned on a northerly track. The cyclonic development was associated with significant upper-trough extension in mid-Pacific, upper-ridge amplification near the west coast of America and upper-trough extension over America. Synoptic experience suggests that such highly amplified patterns often lead in turn to marked meridionality downstream. In December 1962 there was an increasing tendency for amplified patterns in the Atlantic–European sector ; a major block eventually evolved when smaller-scale synoptic features phased into the large-scale upper pattern in such a way as to facilitate a marked Arctic outbreak over Europe. Some retrogression of the blocking pattern immediately took place, as was to be expected from wavelength considerations in view of the marked diminution of zonal flow over a wide sector from the Pacific to Europe ; the severe winter weather therefore settled in over the British Isles as well as most of Europe.

The large-scale blocking pattern over the Atlantic and western Europe dominated the rest of the winter, despite phases of weakening and intensification, slight progression and retrogression. The synoptic-scale developments of December were repeated in various sectors during the winter and operated in such a way as to maintain a blocking mode ; in particular there was repeated cyclogenesis in the east-central Pacific with warm upper-ridge amplification near the west of North America and Arctic outbreaks in broadly the same longitude bands over America and Europe.

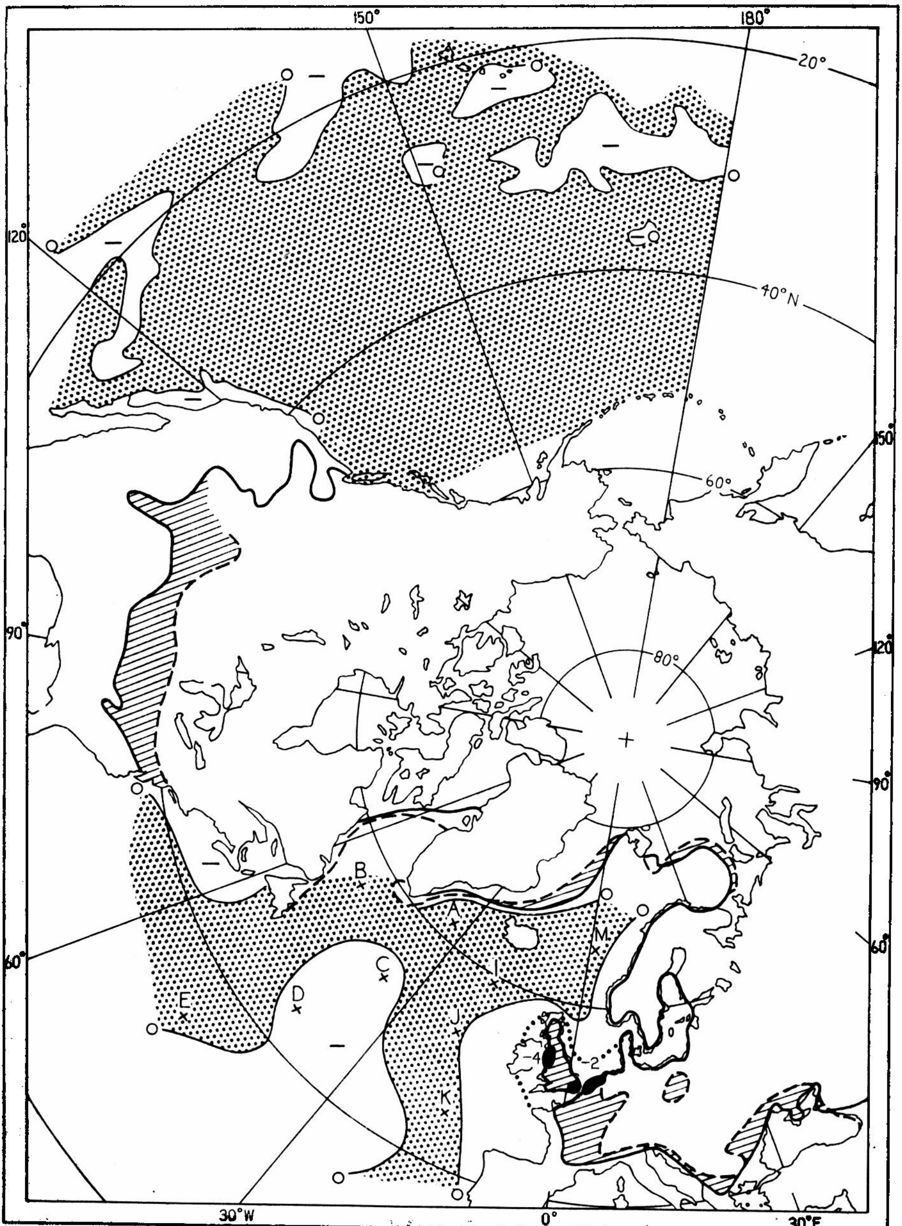
The importance of the sea surface temperature over the North Atlantic in helping to stabilize the blocking mode is not clear. However, it is probably significant that some features of the sea surface temperature anomaly pattern, namely the positive anomalies in high latitudes and negative anomalies farther south in an area including ocean weather stations 'C' and 'D', were broadly analogous to those shown on a map of mean sea surface temperature anomalies, prepared by Namias,[4] for the 27-month period from September 1958 to November 1960 when frequent blocking occurred over and near western Europe. This type of sea surface temperature distribution thus appears to have some characteristics which harmonize with large-scale blocking. Certainly some computations (not reproduced here) of fluxes of latent and sensible heat at the Atlantic ocean weather stations for each of the winter months, show anomalies that appear to be broadly consistent with the anomalous lower-level circulation and the associated surface air

FIGURE 6—*Explanatory notes.*

(*a*) Sea surface temperature anomalies
Isopleths of anomaly are drawn for 0, −2 and −4 degC.
Note : sea surface temperature anomalies over the North Pacific for January 1963 are after Renner[5] and over the North Atlantic for the 10-day period 21–30 January 1963 are based on harmonically smoothed long-period normals from M.O. 527.[6]

(*b*) Snow anomalies
——— Overland — position of the one-inch snow limit over Europe on 27 January 1963 and over North America on 28 January 1963.[7]
— — — Overland — normal position of one-inch snow limit on 31 January.[8]

(*c*) Ice anomalies
——— Oversea — position of Arctic ice limit (i.e. 5/10 or more cover) at end of January 1963.
Note : open water over Baltic but general ice in Gulfs of Bothnia and Finland with patches near the coasts of the southern North Sea and Baltic.
— — — Oversea — normal position of Arctic ice limit at end of January.



Above normal sea surface temperatures. Sea surface temperature anomaly >-4°C (Irish Sea and southern North Sea). Oversea—excess ice; overland—excess snow.

FIGURE 6—COMPOSITE MAP SHOWING THE PHYSICAL STATE OF THE LAND AND SEA SURFACE FOR VARIOUS PERIODS IN JANUARY 1963

See facing page for explanatory notes.

temperature and humidity. For instance, both sensible and latent heat fluxes at ocean weather station 'A' to the south-west of Iceland were below the averages for the period 1950–59, as might be expected qualitatively in view of the weaker winds and moister and more stable air associated with the anticyclonic block in the north-eastern Atlantic.

Another factor of significance was the development of very cold surfaces early in the winter in relatively low latitudes over Europe, America and eastern Asia under the large-amplitude cold upper troughs. The European trough in particular was associated with unusually extensive snow and frozen ground as far south as about 45°N over western Europe, and this favoured intense radiational cooling in the frequently cloudless weather over central and western Europe associated with an airflow from the abnormally cold source in the European Arctic.

An unusually cold surface may help to maintain a cold upper-trough position over a few days. However, unless the circulation itself favours the persistence of a cold surface there will normally be a gradual warming; therefore the abnormal cold surface is not likely to be the major factor controlling the upper-trough position over many weeks.

So far it has not been possible to give a convincing explanation of large-scale circulation developments of the 1962/63 winter. It appears that the physical state of the underlying surface contributed to the stability of the blocking mode, but the complexity of the physical and dynamical feed-back effects on all time-scales is a formidable obstacle to our understanding of general circulation problems. It is hoped that a radical advance in both understanding and prediction will ultimately come from intensive attacks on these problems by modern numerical methods.

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REVIEW

Climates of the U.S.S.R. by A. A. Borisov. 10 in × 6¼ in, pp. xxi + 255, *illus.* Oliver and Boyd Ltd, Tweeddale Court, 14 High Street, Edinburgh 1, 1965. Price : 75*s*.

The Russian contribution to observational meteorology and to the literature of climate has been great, and this good straightforward text on climatology continues a fine tradition. Translated by R. A. Ledward from the Russian edition of 1959, and edited by C. A. Halstead, Lecturer in Geography at the University of Glasgow, it is a commendable work of its kind and it includes a great deal of interesting information, with a useful bibliography. There is a very thorough opening chapter under the title of climate-forming factors, beginning with the radiation régime, and followed by the atmospheric circulation and the characteristics of the air masses with good comments on frequency and on rate of modification. The third section discusses the moisture cycle. It appears that as a result of the work of man in southern Russia the components of the moisture cycle have substantially changed. One can indeed appreciate that determined Russian faith in the prospect of modification of the iron grip of his climate. Recalling the effects of the great Pleistocene water bodies that accompanied the ice age further north, their efforts might fairly derive some encouragement.

It is interesting to read that the average annual radiation balance is deemed to be positive throughout the U.S.S.R. except in the Arctic and other glacial areas ; and there are some informative radiation maps. One can pick out many plums, such as those on p. 27 where a nice table of the number of fronts per annum in different areas is accompanied by a most intriguing map associating the differing extension of ridges of high pressure in the warm and cold halves of the year with the limits of occurrence of certain forest trees.

The style is not without interest to western readers. Frequently the opinions of earlier authorities are compared and criticized against those of their successors and it is evident that the masterly logic of the newer generation prevails. None the less, the work of the great Russian climatologist Voeikov, in the Köppen-Buchan era, is cordially acknowledged. Appropriate regard too is paid to the earlier Lomonosov, who was indeed a surpassingly accomplished scientific pioneer ; although he is here credited with the invention of the anemometer, which many will incline to question. That the first regular notes on the weather were made in the 17th century by watchmen appointed to the Kremlin guard for retention in a secret office seems very proper.

Meteorologists who enjoy the décor of the Moscow hotels will find the solid qualities of this work a little old-fashioned but comforting. Much of it is reminiscent of the earlier Kendrew, although one cannot conceive that classically minded scholar allowing the use of that dreadful word isoline. Geographers will rejoice in the folded maps and others accompanying the critical discussion of classification of regional climates, in which we are led steadily forward to the genetic classification of Alisov. Regional discussion occupies the later part of the book. There is a good chapter on the climates of the seas ; then come the plains and lowlands, and the mountainous areas. Industrialization influences the annual duration of bright sunshine at Leningrad ; with about 1390 hours this approaches 10 per cent less than that of the surrounding country, an effect comparable with, and perhaps exceeding that of London. There is much comment on the remarkably sunny and calm climate of the Yakutsk region along the middle Lena, in addition to the more familiar features around Lake Baikal. The dry warm south-east to east winds — the sukhovei — that cause so much loss of moisture in the marginal agricultural areas bordering the semi-desert steppe are noteworthy, and it is interesting to hear of a 'dry fog' around the Sea of Aral (p. 133) that has not been fully studied. Air-mass frequencies for Central Russia appear to differ on p. 160 from those on p. 95.

We have long appreciated the Russian regard for their vast and spacious land ; it is attractively brought to our minds in the elegant quotation from Turgenev on p. 164. Russian climatology as presented in this book makes a welcome product of a country whose climate is indeed real. Even the most ruthlessly dynamical meteorologist will not fail to find food for thought if he browses among the abundance of well-presented factual material that has been integrated in this commendable work.

G. MANLEY

NOTES AND NEWS

State Meteorological Service of the Federal Republic of Germany

Official notification has been received that Dr E. Süssenberger has succeeded Dr G. Bell as Director of the Deutscher Wetterdienst. Dr Bell retired on 31 July 1966.

METEOROLOGICAL OFFICE NEWS

Dr F. Pasquill—Special Merit Promotion to Deputy Chief Scientific Officer

In 1954 Dr F. Pasquill was promoted to Senior Principal Scientific Officer under the scheme which permits the promotion of scientists of exceptional ability in research without any consequential change in their administrative responsibilities. Since that time Dr Pasquill has continued to be a leading international figure in the study of turbulence and diffusion in the lower atmosphere, and has made several important contributions to the subject. His many colleagues will be delighted that his work has been recognized by his further promotion to Deputy Chief Scientific Officer.

Dr Pasquill's work since 1954 has been carried out first at the Chemical Defence Experimental Establishment at Porton and latterly at the Meteorological Office Headquarters at Bracknell. On the theoretical side he has made contributions to the applications of modern similarity theory to atmospheric turbulence and diffusion. He has also initiated important experimental work in measuring the turbulent energy in the lower atmosphere and in determining the diffusion of airborne material over distances of tens of miles. Dr Pasquill has also been responsible for significant advances in the application of knowledge of atmospheric turbulence to the practical problems of estimating the dispersal of chimney effluents and other aerosols and his book 'Atmospheric Diffusion', published in 1962, fills a serious gap which previously existed in the meteorological literature.

The Meteorological Office is fortunate that as a D.C.S.O. Dr Pasquill will be able to continue to devote his efforts to the important problems of atmospheric turbulence and diffusion.

J.S.S.

Retirement of Mr J. C. Cumming

Mr J. C. Cumming, O.B.E., M.A., retired from the Meteorological Office on 10 August 1966 after more than 36 years service.

Born in Inverness in 1907, Mr Cumming was educated at Robert Gordon's College, Aberdeen, and at Aberdeen University where he read mathematics and natural philosophy.

After graduating, he joined the Office in 1930 as a Junior Professional Assistant in Met.O.4 then in Met.O.2. Appointments at Renfrew, Lerwick and Upper Heyford were followed by a posting in 1938 to Croydon. Overseas service from 1939 to 1943 included posts in Egypt and Palestine and was followed by posts at HQ No. 2 Group, RAF, and with the Four Powers Allied Control Commission in Berlin. Demobilization brought him back to take charge of the Empire School of Navigation Meteorological Office at Shawbury from 1947 to 1949.

For the next 17 years 'Jock' Cumming served civil aviation, firstly at London Airport, then as Head of the Civil Aviation Branch and finally as Chief Meteorological Officer at LAP.

During these 17 years both the LAP Meteorological Office and the demands made on it grew apace from the personalized service given to a relatively few piston-engined aircraft of the late 1940's to the vast forecast factory of today, serving the latest generation of jet airliners not only at LAP but also at many other airports in Britain through the recent development of CAMFAX, the facsimile forecast service for civil aviation centred on LAP as the source. For the major part of this period 'Jock' Cumming was at the helm steering a difficult course between what is technically desirable and what is operationally possible. The existing high regard that aircrew have for LAP Meteorological Office is sufficient tribute to his skill in this role.

Shrewd and knowledgeable in argument with an impish delight in playing 'the Devil's advocate' he gained the unstinted respect of both the Airport Authorities and the Operators. The welfare of his staff and the good name of LAP Meteorological Office were always near to his heart and he was ever quick to rise to their defence.

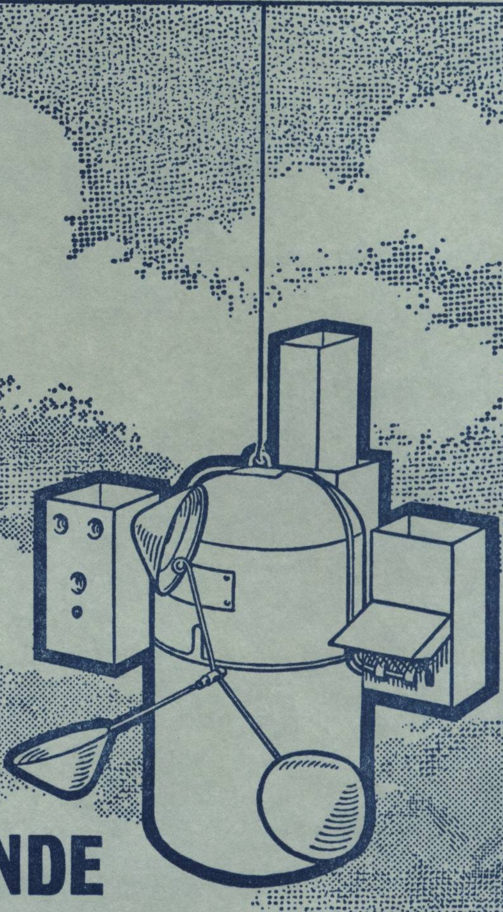
He is widely known in many parts of the Western civil-aviation world both to foreign meteorologists and to airline operators to many of whom 'Jock' Cumming and LAP Meteorological Office are synonymous.

During the 1950's he was a member of the United Kingdom delegation at many meetings of both the International Civil Aviation Organization and the World Meteorological Organization and his knowledge of procedures and recommendations became prodigious.

In the New Years Honours List of 1953 Mr Cumming was made an Officer of the Order of the British Empire.

Mr Cumming is retiring to the West Country and his many friends, both inside and outside the Office, will join me in wishing him and Mrs Cumming many years of happiness in their well-earned retirement.

L. SUGDEN



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