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PLATE I—DR. B. J. MASON, F.R.S.

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DIRECTOR-GENERAL OF THE METEOROLOGICAL OFFICE

Dr. B. J. Mason, F.R.S., has been appointed to succeed Sir Graham Sutton as Director-General of the Meteorological Office from 1 October 1965.

Dr. Mason comes of a Norfolk family and his early education was at Fakenham Grammar School. After commissioned service in the Radar Branch of the Royal Air Force during the war he graduated in 1947 at Nottingham University with first class honours in physics. The next year he joined the Department of Meteorology at the Imperial College of Science and Technology, University of London, where he quickly became immersed in the study of microphysical processes in clouds. During this period he found a fruitful collaborator in Dr. F. H. Ludlam, whose interests lay more in the macrophysical aspects of cloud formation. The outstanding characteristic of Dr. Mason's work in this field is undoubtedly his skill in devising laboratory techniques for the investigation of problems of condensation and freezing in the atmosphere—for example, his use of the diffusion cloud chamber to ascertain the dependence of the structure of ice particles on temperature and supersaturation. His book, *The Physics of Clouds*, published in 1957, was quickly recognized as an authoritative and, in many respects, original contribution to meteorology. The same year he was appointed a Warren Research Fellow of the Royal Society and in 1960 his eminence in his chosen field led to his appointment to a newly-created Chair of Cloud Physics at Imperial College. Soon after this he evolved a novel theory of thunderstorm formation which is regarded by many as the best yet produced in this notoriously difficult field. Earlier this year he was elected to the Fellowship of the Royal Society at the early age of 41.

Dr. Mason is well known to the staff of the Meteorological Office and his long service with the Meteorological Research Committee has made him familiar with many of the problems of the professional worker. The Office will benefit greatly, not only from his knowledge and skill, but also from the drive and enthusiasm that he brings to all his interests.

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A CLIMATIC SINGULARITY IN JUNE 1964 IN SOUTH-EAST ENGLAND

By E. N. LAWRENCE, B.Sc.

During the first 19 days of June 1964, a total of about four inches of rain, often with thunderstorms, was recorded at Kew (see Table I) and sufficient rain fell in south-east England to constitute one of the wettest Junes of this century. The period was characterized mainly by cyclonic pressure patterns in the region of the British Isles, while during the first 10 days or so pressure was rather high between Greenland and northern Norway; over Britain, the thermal wind (1000–500 mb) was predominantly south-westerly; during early June, the Azores anticyclone did not extend towards the British Isles until the second week and then only temporarily; from the 17th to 19th, the pressure pattern became anticyclonic in the Atlantic area west of Ireland, at least up to the 500 mb level. After the 19th the Azores 'high' persistently extended to the British Isles to assume a more normal synoptic pattern,[1] and to give mainly dry weather over south-east England for the remainder of June and early July. This anticyclonic period was in complete contrast to both the earlier part of June and to May, when the Azores anticyclone was weak and extended to the Atlantic area west of Ireland much less frequently than usual (cf. figures given by Newnham[2]).

This June 1964 rainfall pattern or sequence illustrates a well-known climatic singularity or weather episode, that is a period of weather around a particular time of the year which in some years is very well marked but which occurs to some extent in most years and is characteristic of an area. This June singularity is sometimes referred to as the 'European summer monsoon' because of the tendency for land–sea differential heating effects in May and June, as in the well-known Indian monsoon. The concept of weather singularities and other examples are further discussed elsewhere.[3,4,5]

The main dates of the 'summer monsoon' in Europe are stated by Brooks[3] as 1–21 June, and these dates are partly confirmed by Lamb,[4] whose frequency curves for long spells of persistent weather show 17–18 June as a date of seasonal discontinuity. Further evidence of this June singularity is given in Table II which shows the yearly dates (since 1871, the earliest available record) when there were more than 10 wet days (of rainfall >1 mm) at Kew during the period 1–20 June, and also the number of subsequent wet June days. It can be seen from Table I that June 1964 followed a pattern similar to the other Junes of Table II.

The Junes of Table II were all distinctly wetter than normal, apart from June 1894 which was only a little wetter than average. These wet Junes all ended in a mainly dry spell which extended well into July (except in 1912).

The June 1964 singularity followed a period in which there were particularly marked singularities of the type associated with land–sea differential heating. A recent paper by Baur[6] draws attention to the exceptionally unbroken series of singularities (anticyclonic and cyclonic) during the previous winter and the unusually large amplitudes of the associated 30-day pressure wave over central Europe, unprecedented for over 200 years. The winter, December 1963 and January and February 1964, was the driest in England for over 200 years.[7] A striking feature of the winter circulation was its extremely

TABLE I—RAINFALL AT KEW DURING JUNE 1964 FOR 24-HOUR PERIODS BEGINNING 0000 GMT

Date	Rainfall mm	Date	Rainfall mm
31 May	12.3	16 June	0.0
1 June	20.1	17	4.5
2	tr	18	30.1
3	0.1	19	4.2
4	8.6	20	1.2
5	3.3	21	0.0
6	0.6	22	tr
7	7.0	23	tr
8	tr	24	tr
9	0.0	25	0.0
10	0.0	26	0.0
11	0.0	27	0.0
12	11.4	28	tr
13	4.1	29	0.0
14	3.6	30	0.0
15	tr	June total*	98.8

The line after 20 June indicates the termination of the wet spell.

*The mean total rainfall for June (1916–50) at Kew is 43.7 mm.

TABLE II—NUMBER OF DAYS (0000 TO 2400 GMT) WITH RAINFALL MORE THAN 1 MM AT KEW FOR YEARS WITH 11 OR MORE SUCH DAYS DURING 1–20 JUNE, 1871–1964

Year	1894	1902	1912	1924	1926	1935	1946	1964
1–20 June	12	11	12	11	11	14	12	11
21–30 June	0	1	4	0	0	1	4	0

meridional circulation. Further climatological records were broken during March, April and May of 1964. All such singularities and records[7,8] could help towards or reflect the build-up of a marked European summer monsoon.

The wet period in June was so marked that it might be recognized as a singularity and so alert the forecaster to the possibility of the wet period coming to an end with a change to dry weather after about 20 June. Synoptic charts provided the final clue as to the date of change by showing an extension of the Azores high towards the British Isles on 20 June.

The dates of Table II bear a striking relation to the sunspot cycle, as can be seen from the following dates of sunspot minima given by Waldmeier:[9]
1901.7, 1913.6, 1923.6, 1933.8, 1944.2, 1954.2, 1964 (approx.)
The only sunspot minimum years not associated with dates of Table II are 1879 and 1890 which had the two wettest Junes of the nineteenth century, and 1954 which had an extremely dull, cool and wet summer in England and Wales and an unusual pressure distribution which could be a reflection of a very strong monsoonal effect.[10,11,12]

Not all the years which showed the marked June 'wet to fair weather' sequence had marked monsoonal conditions, as in 1964. A similar sequence could result from a prevailing zonal flow being displaced by a slight seasonal northward movement of the subtropical high-pressure belt.

Work described elsewhere[13] suggests an association (1) between the 'monsoonal' type of June singularity and sunspot minima, at least when following large solar amplitudes and (2) between the 'zonal' type of June singularity and the years of increasing sunspots, at least in small-amplitude solar cycles.

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EASTERLY WINDS AND LOW STRATUS AT LEUCHARS

By L. L. ALEXANDER

Summary.—The occurrence of cloud with base below 1000 feet in easterly surface winds at Leuchars is examined statistically over a long period—1950 to 1963. Factors examined include the 900 millibar wind, the lapse rate, the dew-point depression and the difference between dew-point and the sea temperature. Different stratus effects are noted for three types of easterly surface winds. An attempt is made to differentiate between small amounts of low cloud and low cloud of amount $\frac{5}{8}$ or more. Little difference is noted between day and night occurrences or for different wind speeds, though the frequency of stratus at 300 feet and below tends to decrease with increasing wind speed. The main conclusions are listed at the end.

Introduction.—The reputation of Leuchars for weather favourable for flying is marred by the frequency and quick onset of very low stratus with easterly winds. The problem of forecasting the stratus onset is made difficult by the lack of observing stations to the east. Investigations over short periods have been made from time to time without producing any convincing technique for forecasting stratus. It was decided therefore to attempt a long-term statistical investigation in the hope of finding some common factors which would increase the percentage of successful forecasts. The investigation extended over the whole years 1950 to 1959 for certain aspects and, later, 1960 to part of 1964 was included. The material used was that which is readily available to the forecaster at Leuchars, i.e.:

Hourly observations at Leuchars;
Radiosonde ascents at Leuchars (Shanwell from September 1959);
Sea temperatures at Bell Rock;
Average sea temperature charts.

Topography of the area.—Figure 1 is a map showing the sea area to east and south of Leuchars and the high ground in the vicinity. The immediate

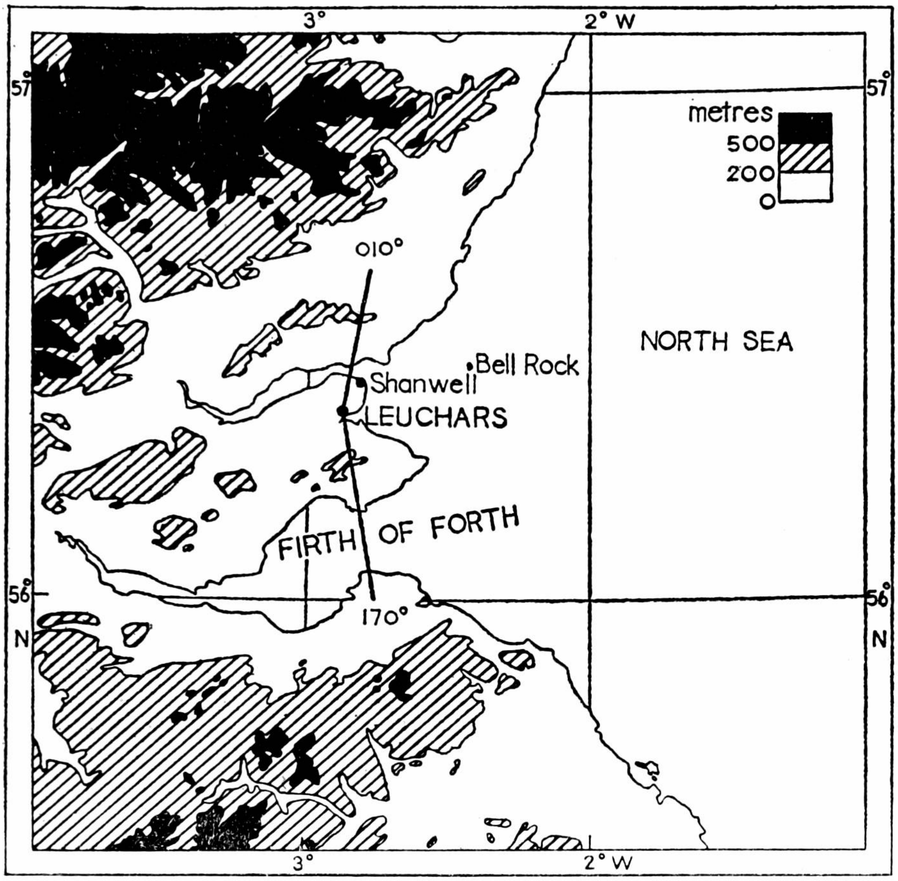

FIGURE I—MAP OF THE LEUCHARS AREA

southern boundary of the aerodrome is the estuary of the River Eden; at low tide, the estuary is drained almost entirely to mud flats. The effective coastline may be important in those borderline cases where stratus exists over the sea but not over the land. An example of this has been described by Alexander.[1]

Statistics of easterly surface winds and incidence of stratus.—

TABLE I—MONTHLY AND ANNUAL PERCENTAGE OF EASTERLY WINDS WITH AND WITHOUT STRATUS, BASED ON HOURLY WIND OBSERVATIONS FOR THE 14-YEAR PERIOD 1950–63

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
						percentage							
Without stratus	17	19	27	25	31	25	21	20	18	16	17	14	21
With stratus	3	6	13	8	14	14	13	12	9	8	7	3	9

Note 1.—Monthly or annual number of hourly occurrences are averaged over 1950–63 and expressed as a percentage of the total number of hourly observations in each month or in a year.

Note 2.—'Easterly' means with an easterly component, i.e. 010° to 170°.

Note 3.—'Stratus' means ⅛th or more lower than 1000 feet.

Table I shows that easterly winds and low stratus are most frequent from March to August but Table II shows there is no clearly defined season for maximum frequency of low stratus with easterly winds.

TABLE II—MONTHLY MAXIMUM AND MINIMUM PERCENTAGE FREQUENCIES* OF EASTERLY SURFACE WINDS FOR THE PERIOD 1950–63, AND THE YEAR OF OCCURRENCE

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
(a) Maximum percentage frequencies													
Without stratus		1963	1955	1960	1956	1951	1955	1962	1955	1952	1952	1950	1958/59
		46	32	60	38	50	37	34	34	31	33	24	28
With stratus		1952	1963	1960	1961	1951	1958	1957	1957	1956	1960	1963	1953
		7	14	26	32	27	35	25	22	26	36	25	19
(b) Minimum percentage frequencies													
Without stratus		1952	1952	1961	1950	1956	1952	1953	1961	1955	1957	1953	1951
		4	5	1	15	12	10	10	8	7	3	8	2
With stratus		1953	1952	1961	1950	1961	1962	1954	1953	1955	1950	1956	1951
		0	0.3	0.5	0.5	1	0.5	2	4	0.1	0.1	0.1	0.1

*Extremes for the 14-year period 1950–63 are expressed as a percentage of the total number of hourly observations in each month.

'Stratus' means ⅛ or more lower than 1000 feet.

Table II shows the great variability of occurrences of stratus with easterly winds. It also shows that the periods of maximum easterly winds are not necessarily periods of maximum stratus.

Relationship between speed of easterly surface winds and cloud heights.—An attempt was made to relate the height of the cloud base in easterly surface winds to the speed of the wind. No conclusive relationship could be found. Little difference could be found between the day and night occurrences or for different wind speeds. The frequency of cloud at 300 feet or lower tends to decrease with increasing wind speed but occasions have been noted when there has been stratus at 200 feet by day with the surface wind over 21 knots.

Relationship between the 900 millibar wind and the occurrence of stratus with easterly surface winds.—It is known that when the surface wind at Leuchars has an easterly component there may be wide differences between its direction and that of the gradient wind. A random selection was made from the 900 millibar winds found by radiosonde at Leuchars (Shanwell from September 1959), the only proviso in the selection being that the surface wind must have an easterly component. The selection covered various months and years between 1955 and 1964 and was almost equally divided between day and night soundings.

In Table III, it can be seen that the 900 millibar winds examined divide roughly equally between 010 and 040 degrees and 180 and 240 degrees on the one hand and 050 to 170 degrees on the other (136 occasions to 155 occasions).

TABLE III—RELATIONSHIP BETWEEN 900 MB WIND DIRECTION AND THE OCCURRENCE OF STRATUS WITH EASTERLY SURFACE WINDS

900 millibar wind (sector)	Number of occasions with cloud below 1000 feet	Number of occasions examined*
degrees		
010 to 040	5	39
050 to 170	130	155
180 to 240	15	97

*Random selection from occasions of easterly surface winds, 1955–64.

Using this division, it can be seen that 20 of 136 occasions gave stratus with the first grouping and 130 of 155 occasions with the second grouping. It seems to the author that the direction of the 900 mb wind could be a helpful parameter to use in the forecasting of stratus on days with easterly surface winds and suitable temperatures.

Lapse rates and incidence of stratus.—Of the 291 occasions used in Table III, tephigrams were studied for 89 of the Shanwell radiosonde ascents involved. These were all in the months of June and November 1963, and March, April and May 1964. Approximately half the ascents were made at noon and half at midnight.

These ascents were divided into four types:

(i) Inversion from the surface to 900 millibars.

(ii) Inversion near the surface then isothermal or with a lapse to 900 mb.

(iii) Lapse to 900 millibars.

(iv) Lapse near the surface then inversion to 900 millibars.

TABLE IV—OCCURRENCE OF STRATUS ON CERTAIN OCCASIONS IN 1963 AND 1964 IN RELATION TO TEMPERATURE VARIATIONS UP TO 900 MB

	Inversion from surface to 900 mb		Inversion near surface then lapse to 900 mb		Lapse to 900 mb		Lapse near the surface then inversion to 900 mb	
900 mb wind (sector)	Stratus		Stratus		Stratus		Stratus	
	Absent	Present	Absent	Present	Absent	Present	Absent	Present
degrees	*number of occasions*							
010 to 040	0	0	0	1	6	1	0	1
050 to 170	0	1	7	12	19	8	0	12
180 to 240	0	0	2	1	10	5	0	3

'Stratus' means ⅛ or more lower than 1000 feet.

The number of ascents used (89) in Table IV is not sufficient to form definite conclusions but is sufficient to show that stratus can occur with any type of lapse rate. In particular, it seems from Table IV that stratus formation is associated with the occurrence of an inversion above the layer close to the surface. There is also in Table IV an indication that stability near the surface is not a certain sign of stratus formation and that instability is no bar to stratus formation.

Sea temperatures.—Sea temperatures recorded at Bell Rock were tabulated for April, May, June and July from 1950 to 1958, and for the whole years from 1959 to 1963. No consistent relationship could be found between the frequency of low stratus at Leuchars and above or below average sea temperatures recorded at Bell Rock. The readings were compared with the sea temperature averages prepared by the Fisheries Laboratory, Lowestoft, and issued to Meteorological Offices in 1960. There were few departures from these averages greater than 2 degrees Celsius.

Critical surface temperatures and stratus formation.—The sea temperatures at Bell Rock and the dry-bulb temperature and dew-point depression at Leuchars were combined in an attempt to find a relationship which could be used as a stratus formation indicator.

Table V could be used:

(*a*) as an aid in timing the onset of low stratus according to forecast temperatures, (*b*) in forecasting the probability of low stratus and

(*c*) in forecasting the probable amount of low stratus.

TABLE V—OCCURRENCE* OF STRATUS IN EASTERLY WINDS AT SYNOPTIC HOURS, 1959–63, ANALYSED ACCORDING TO DEW-POINT DEPRESSION AND DIFFERENCE OF DEW-POINT AND SEA TEMPERATURE

Dew-point depression at Leuchars *deg C*	Dew-point at Leuchars minus sea temperatures at Bell Rock *degrees Celsius*								Amounts of cloud below 1000 feet
	3 or more	2	1	0	−1	−2	−3	−4 or more	
	percentage								
4 or	(0)	(0)	4	0	3	0	1	0	1/8–4/8
more	(0)	(0)	0	0	0	0	0	0	5/8–8/8
3	(20)	(20)	14	17	8	15	7	1	1/8–4/8
	(0)	(0)	0	3	3	2	0	0	5/8–8/8
2	(29)	(22)	34	24	17	17	17	4	1/8–4/8
	(0)	(33)	28	26	8	13	7	2	5/8–8/8
1	(0)	8	22	26	21	31	17	19	1/8–4/8
	(0)	54	47	51	52	29	13	7	5/8–8/8
0	(0)	(10)	11	9	7	42	18	10	1/8–4/8
	(100)	(80)	78	81	83	32	45	7	5/8–8/8

*Expressed as a percentage of all observations with easterly winds which had the same difference between the dew-point at Leuchars and the sea temperature at Bell Rock and the same dew-point depression at Leuchars; percentages are given in brackets if based on 10 or less observations.

Types of synoptic situations producing easterly winds.—There are three main types of synoptic situations which give easterly surface winds at Leuchars. These are:

(i) sea breeze,

(ii) backing wind ahead of a warm front (transient easterlies) and

(iii) long-term easterlies (persistent easterlies).

Each of these situations was examined.

(i) *Sea breeze.*—It was extremely difficult to decide whether an easterly wind was a 'sea breeze' or not, so sea-breeze occasions were chosen according to two criteria: (1) when anticyclones were centred directly over the area so that any easterly surface wind which occurred was not influenced by any gradient wind, and (2) occasions when the surface wind became easterly after 0600 GMT and dropped to calm or became westerly by about 2200 GMT and when no signs of pre-frontal cloud were evident.

Of 68 sea-breeze occasions thus chosen in the years 1950–59 and during the months April, May, June and July, only 4 produced any stratus. On all 4 occasions there had been radiation fog at Leuchars prior to the onset of the sea breeze and this fog had been taken out to sea by westerly winds. Therefore it can be stated with reasonable confidence that sea breezes as defined above do not produce stratus at Leuchars.

(ii) *Transient easterlies.*—At Leuchars, the surface wind is backed considerably when the gradient wind is southerly. Under these conditions, stratus is a common occurrence. For stratus to form with a very short sea track, the advection of very moist air seems a necessity and this is most likely to occur with an approaching warm front. Normally, any stratus formed by this method would only last a few hours, hence the name 'transient easterlies'.

(iii) *Persistent easterlies.*—The long-period easterly wind is the result of a settled anticyclone over Scandinavia or to the north of Scotland. It is seldom a difficult matter to differentiate between the 'transient' and the 'persistent' types and rarely does the transient develop into the persistent easterly.

Comparison of transient and persistent easterlies.—The time of onset (defined as the time of the hourly observation first showing the phenomenon) of the easterly wind was compared with the time of onset of stratus. The delay in arrival of stratus was greater with persistent easterlies than with transient easterlies as shown in Table VI.

TABLE VI—COMPARISON OF TRANSIENT AND PERSISTENT EASTERLIES IN RELATION TO STRATUS, APRIL–JULY, 1950–59

	Total number of days	Number of days with stratus	Number of days with stratus and rain	Delay of arrival of stratus* in hours With rain	Without rain
Transient easterlies	198	59	52	3·6	9·3
Persistent easterlies	487	232	16	15.2	32.8

*Average delay in arrival of stratus after the onset of the easterlies. The delay ranged from 0 to 14 hours for transient and 1 hour to 2½ days for persistent easterlies.

It can be seen from Table VII that there is a slightly better chance of the stratus at its onset being more broken with transient easterlies than with persistent easterlies.

TABLE VII—HEIGHT AND AMOUNT OF STRATUS AT ITS ONSET,* APRIL–JULY, 1950–59

Height of stratus	Transient easterlies Amount of stratus 1/8–2/8	3/8–4/8	5/8–8/8	Totals 1/8–8/8	Persistent easterlies Amount of stratus 1/8–2/8	3/8–4/8	5/8–8/8	Totals 1/8–8/8
feet	*number of occasions*				*number of occasions*			
0				0			14	14
100	1		1	2				0
200–300	1	1	6	8	1		10	11
400–500	1	8	13	22	2	2	13	17
600–700	3	4	7	14		3	28	31
800–900		4	9	13		5	27	32

*Defined as the time of the hourly observation first showing stratus.

Main conclusions.—

(i) There is no sharply defined season for stratus with easterlies, though easterlies and stratus are most frequent from March to August (Tables I and II).

(ii) The occurrence of easterly winds in any month varies greatly from year to year as does the proportion of easterlies with stratus (Table II).

(iii) The occurrence of stratus with easterly surface winds is more frequent with:

(*a*) 900 mb winds between 050 and 170 degrees (Table III),
(*b*) an inversion below 900 mb with an unstable surface layer (Table IV),
(*c*) a small dew-point depression (Table V),
(*d*) a small difference between the sea temperature and the dew-point (Table V).

(iv) Easterlies may be classified as persistent, transient, or sea breeze.

(*a*) The persistent easterly type may be prolonged but is usually dry and produces stratus which most often begins as 5/8 to 8/8 after an average time of 15 to 30 hours (Tables VI and VII);

(*b*) Transient easterlies ahead of a warm front do not last long, are often accompanied by rain and, after an average time of 3 to 9 hours, produce stratus which quite often begins as 4/8 or less (Table VI and VII);

(*c*) Stratus is not formed by a sea breeze but existing stratus over the sea may be brought over land by a sea breeze.

(v) In borderline cases where stratus exists over the sea but not over the land, the stratus may encroach on the aerodrome more easily at high tide than at low tide because the coastline is nearer the aerodrome at high tide.

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551.509.325

FORECASTING FOG CLEARANCE AT WITTERING

By N. J. ATKINS

In order to forecast the time of fog clearance by Kennington's method[1] it is necessary to have a physical measurement of the height of the fog top, and Barthram's diagrams[2] can then be used as a convenient way of computing the time of clearance. Many stations are too far away from radiosonde stations for a representative measurement to be available and this paper describes an empirical method of assessing a fog from other known factors so as to get an approximate fog top which can be used on Barthram's diagram. The following factors were taken into account at the time of the forecast:

(i) surface visibility,
(ii) whether the sky was visible or not,
(iii) wind direction and
(iv) air temperature.

This paper applies to one particular station, Wittering, where an examination of 52 cases of radiation fog between August 1960 and October 1964 led to the five classes listed in Table I. In effect the height of fog top is estimated from the visibility.

TABLE I—FOG CLASSES FOR USE WITH BARTHRAM'S DIAGRAMS[2]

Class	Description	Procedure
A	Visibility greater than 200 yd, sky visible.	Assume depth of fog 10 mb
B	Visibility 200 yd or less, sky visible	Assume depth of fog 15 mb
C	Sky not visible	Assume depth of fog 30 mb
D	Visibility 150 yd or less, sky not visible, surface wind has an easterly component	Determine clearance time assuming depth of 30 mb and add special fog correction from Table II
E	Freezing fog, sky not visible	As class *D*

Wittering is on sloping ground, low to the east, and the thicker fogs drift from that direction; it is therefore necessary to add a special correction (given in Table II) to the clearance time whenever at the time of the forecast the surface wind has an easterly component and the visibility is 150 yd or less with the sky obscured. The same correction is made for freezing fog when the sky is not visible.

The large correction of 2 hours or more for topographical reasons, shown in Table II, is interesting; there seem to be no intermediate corrections of less than 2 hours. This fact is borne out by Table III which is an analysis of the number of late clearances without the special fog correction applied and the number of early clearances with the special correction applied. Only one occurrence, marked with an asterisk, required an intermediate correction. It is suggested that there is a limiting value to the water content of the radiation fog and that there is a marked increase in water content (probably in the form of larger droplets) as soon as the fog becomes semi-orographic.

TABLE II—SPECIAL FOG CORRECTION

Month	Jan. Dec.	Feb. Nov.	Mar. Oct.	Apr. Sept.	May Aug.	June July
Correction (hours)	+2	+2	+2½	+2½	+2	–

The special fog correction is added when visibility is 150 yd or less, the sky is not visible and the surface wind has an easterly component.

TABLE III—COMPARISON BETWEEN LATE CLEARANCES WITHOUT SPECIAL FOG CORRECTION AND EARLY CLEARANCES WITH SPECIAL FOG CORRECTION

	Without special fog correction applied—late clearing				With special fog correction applied—early clearing			
Hours	¼	½	¾	1	1	¾	½	0
Cases	5	5	3	0	1*	0	2	1

These figures verify that there seems to be no intermediate corrections of less than 2 hours, with the exception of the value marked with an asterisk.

In preliminary investigations there was a marked tendency for forecast times of clearance at Wittering to be too early, perhaps because moisture is evaporated from the vegetation in the partly-wooded agricultural surroundings. This tendency can be reduced if the fog clearance temperature (T_2 in Kennington's notation) is obtained by adding 2 degrees C to the dew-point observed at the time of fog formation. Such a value of T_2 is even higher than would be obtained by assuming a dry-adiabatic lapse rate from surface to a fog top of 600 feet. A comparison between the high value of T_2 and the actual fog clearance temperature is shown in Table IV for the 43 cases of clearing fog investigated. One advantage of this method of obtaining T_2 is that it is possible to make a reasonable forecast of the time of clearance even before the fog has

TABLE IV—COMPARISON OF ACTUAL FOG CLEARANCE TEMPERATURE WITH THE FORECAST VALUE, T_2, OBTAINED BY ADDING 2 DEGREES CELSIUS TO THE DEW-POINT AT THE TIME OF FOG FORMATION

	T_2 minus actual clearance temperature								
	Positive (T_2 too high) *degrees Celsius*				Zero (similar)	Negative (T_2 too low) *degrees Celsius*			
	4	3	2	1		1	2	3	4
Cases	0	1	7	8	23	3	0	0	1

actually occurred—by basing the calculation on the expected minimum temperature and a dew-point 2 degC above the fog-point with an appropriate assumed depth of fog.

In winter there may be no clearance because insufficient insolation is received, or there may be no real clearance because an improvement to mist is quickly followed by fog again.

Figure 1 is a reproduction of part of Barthram's graph showing the time by which insolation available for dispersing the fog will have been received, but an additional dashed line has been added as an aid in forecasting the occasions of no real clearance. There will be no real clearance if the final estimate of the insolation value required to clear a fog falls to the right of the dashed line which has been constructed by studying previous occurrences at Wittering.

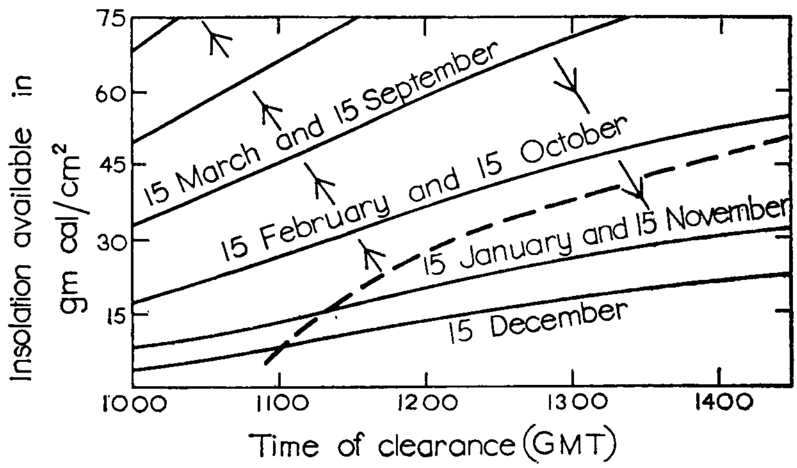

FIGURE 1—BARTHRAM'S DIAGRAM, SHOWING INSOLATION AVAILABLE BY VARIOUS TIMES, MODIFIED FOR FORECASTING OCCASIONS OF NO REAL FOG CLEARANCE AT WITTERING

There will be no real clearance if the final estimate of the insolation value required to clear fog falls to the right of the dashed line.

Although the cases were not entirely independent of the method of constructing the line of no clearance, it is interesting to note that of the 10 cases in which no clearance was forecast, 9 were correct and only 1 was incorrect. On the 43 occasions when a clearance occurred, 33 forecasts were correct to within ½ hour and 40 were correct to within 1 hour. These figures should be compared with those found by Heffer[3] in his tests of Kennington's method based on a more precise estimate of the height of fog top.

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551.509.325

FORECASTING FOG CLEARANCE AT GAYDON, COTTESMORE AND WATTON

By T. D. D. JENNINGS, C. J. MACEY and B. L. GILES

An empirical method of assessing the height of fog top and the time of fog clearance has been described by Atkins[1] for Wittering, a station with rather special topography. The success which Atkins achieved encouraged the authors to try his method at three other stations each with its own local topography. The results are given in Tables I and II.

TABLE I—ANALYSIS OF FORECASTS OF FOG CLEARANCE AT GAYDON, COTTESMORE AND WATTON

Station	Period	Total number of fogs	Number of fogs used in the test	Clearance temperature forecast to within 0.5 degC	Clearance temperature forecast to within 1.0 degC	Clearance time forecast to within ½ hour	Clearance time forecast to within 1 hour
	months			*number of occasions*		*number of occasions*	
Gaydon	47	179	50	13	25	21	30
Cottesmore	80	373	48	15	27	10	18
Watton	40	92	54	17	30	19	31

Note: in Atkins' investigation of 52 cases of radiation fog at Wittering, the forecast clearance time was correct to within ½ hour on 33 occasions and to within 1 hour on 40 occasions.

TABLE II—ANALYSIS OF FORECASTS OF PERSISTENT FOG AT GAYDON, COTTESMORE AND WATTON

Station	Forecast of no clearance: Correct	Forecast of no clearance: Incorrect	Incorrect forecast of clearance
	number of occasions		*number of occasions*
Gaydon	2	1	1
Cottesmore	3	3	4
Watton	3	3	1

Note: in Atkins' investigation at Wittering, 9 out of 10 occasions of no clearance were correctly forecast.

The figures entered under total number of fogs show the number of mornings when water-droplet fog was reported. The next column shows how many of these fogs appear to have cleared by radiation without detectable interference by other processes. At all three stations such fogs are only a fraction of the total. The figures should be compared with those given by Heffer[2] for Wyton; he found that only 40 out of 122 apparent radiation fogs were uninfluenced by advection in the period between midnight and dawn.

Cottesmore is 460 feet and Wittering is 275 feet above mean sea level. They are only 12 miles apart and both are situated near the top of the slope which rises westwards from the fens to the relatively high ground of the Lincoln Edge and the Northamptonshire Uplands. Although the exposures of these two airfields have many common features, it is evident from Table I that the behaviour of fogs is different at each. Thus Atkins' method, which works so well at Wittering, cannot be used at Cottesmore.

At Gaydon, 430 feet above mean sea level on the crest of a hog's back ridge and a few miles west of the main hills of the Northamptonshire Uplands, the method was more successful. Only with a surface drift from the west is there local up-slope motion at Gaydon and the investigation there was first carried out without applying the delaying factor for easterly drift which Atkins stipulates for Wittering. However, it was found that fogs with drifts having an easterly component are subject to delayed clearance and after a few trials it was found that the values which Atkins devised for Wittering were also best suited to Gaydon, even though the local topography is different. This special correction has been applied, where appropriate, to the figures for Gaydon given in Table I.

Watton's situation is quite different from that of any of the other stations. It is about 190 feet above mean sea level on the East Anglian Heights and its immediate surroundings are rather flat. Preliminary tests showed that the Atkins' special correction for thicker fogs with easterly winds did not apply to Watton and better results were obtained when 1.5 degrees C instead of 2.0 degC were added to the dew-point to obtain the forecast temperature of clearance, T_2. Further tests also showed that the correction of +2 hours should be retained for freezing fogs with sky obscured.

Conclusions.—Atkins' method has now been tried at four stations. At three of these stations—Watton, Gaydon and Wittering itself—the method gives useful results. At Cottesmore the method failed and experience at Watton shows that the method should not be applied to any other station without preliminary investigation of both the effectiveness of a delaying factor similar to Atkins' correction for easterly winds and the most suitable addition to the dew-point to obtain the forecast temperature of clearance.

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551.5:061.3:523

THE SIXTH INTERNATIONAL SPACE SCIENCE SYMPOSIUM, MAY 1965

The Committee on Space Research (COSPAR), established by the International Council of Scientific Unions (ICSU), have, over the past six years, held an annual Symposium at the time of the Committee's plenary meetings. The Symposium was to have been held this year from 13 to 19 May, at Buenos Aires but it was decided to hold it instead at Mar del Plata. The efficiency of the Argentinian organizers in transferring 300 participants, together with all the paraphernalia of a major symposium, a distance of 250 miles cannot be too highly praised.

The Symposium comprised sessions on five 'Special Topics' (Galactic and Extragalactic Space Research; Problems of Atmospheric Circulation; Southern Hemisphere Anomalies; Optimisation of Instruments of Space Experiments from the Standpoint of Data Processing; and Life Sciences); sessions on 'Latest Significant Results'; and Open Meetings of the five COSPAR Working Groups (Tracking, Telemetry and Dynamics; the International Years of the Quiet Sun; Data and Publications; the International Reference Atmosphere; Space Biology). A vast number of papers were presented with, in some cases, no time at all allowed for questions and discussion (and since some speakers left as soon as they had delivered their paper there was not always opportunity for discussions outside the formal meetings).

In the sessions on the Atmospheric Circulation two projects involving the use of balloons and satellites were described. In both projects the balloons float at a constant height and transmit measurements of pressure and temperature. These transmissions will be received by a satellite, for subsequent read-out on command. By repeated 'fixes' on each balloon, from the satellite, wind speeds and direction would also be determined. In the EOLE project, planned by the French National Space Centre, 512 balloons would be released in the southern hemisphere in 1968. The GHOST project, planned by the U.S.A. National Center for Atmospheric Research, envisages many thousands of balloons continuously in the air. A preliminary programme is planned for 1965/6 in which 5000 balloons will be launched in the southern hemisphere, at three levels: 500, 200 and 30 millibars. In this preliminary programme, data transmissions will be received by ships.

In connexion with these constant-level balloon programmes it was pointed out by Dr. Mintz (U.S.A.) that the balloons would tend to accumulate in certain regions, e.g. at 500 mb in the tropical convergence zone, and he suggested that devices be incorporated whereby balloons could be commanded to move to a new level.

Dr. Mintz's comment arose out of a description he gave of his global numerical prediction technique. Using a relatively simple model he found that, starting from an isothermal atmosphere everywhere at rest, a situation quite similar to reality was achieved in about 30 days; and that thereafter the situation showed changes which were, in scale and intensity, very like what occurs in the real atmosphere. He remarked, in passing, that although in his model the Siberian anticyclone was well represented, it disappeared if he removed the Himalayas.

Rasool and Prabhakara (U.S.A.) reported on an analysis of TIROS radiation data and concluded that there is something approaching a radiation balance, over a complete year, for each hemisphere separately. This, in itself, does not appear especially surprising but the authors stated that there is good evidence for a net northward flow of latent heat (water vapour) across the equator and this must, they suggested, be compensated by a southerly flow of sensible heat, by either air or sea currents. (Incidentally, it was announced that the Automatic Picture Transmission System, planned for the Operational Weather Satellites (TOS) will include infra-red 'television' as well as cloud photography.)

Dr. Newell, in almost the only reference to the 26-month 'cycle', repeated again his suggestion that this could be accounted for by a 26-month solar cycle which need have an amplitude no greater than 0.1 per cent in radiation intensity.

Several speakers presented, and briefly discussed, results of 'meteorological rocket' firings during the previous 12 months in various parts of the world.

Finally there were papers about eddy diffusivity at high levels. In one a study of the measured concentrations of atomic and molecular oxygen led F. S. Johnson (U.S.A.) to conclude that "the average eddy (vertical) diffusivity between 80 and 105 km cannot be much larger than 10^6 cm^2sec^{-1}. This is ten to a hundred times smaller than values frequently quoted on the basis of vapour trails released from rockets".

R. FRITH

AN ANALYSIS OF TROPICAL STRATOSPHERIC WINDS BY MEANS OF A BAND PASS FILTER TECHNIQUE

By GERALDINE E. EDMOND

In this investigation of the periodicity of tropical stratospheric winds the data selected were the monthly mean zonal wind components for Singapore at 60,000 feet and for Canton Island at 50 millibars (approximately 68,000 feet) as these were the longest records available. The period covered by each set of data was from January 1954 to June 1964, giving in all 126 monthly values.

In order to detect which were the major oscillations in the series of observations, thirteen 25-point filters, designed by Craddock[1] (see Appendix), were applied to each set of data. Each filter is, in fact, a set of weights and is used to calculate for each term of the series a weighted average incorporating a given observation and the 12 observations on either side of it. The resultant series of filtered data is therefore shorter than the original data by 12 terms at either end. In the simplest form of filter used the weights are equal and the resulting series is a 24-month moving average which portrays the long-period trend of the observations. The weights of the other filters are so designed that oscillations within a certain band of periods are preserved, while oscillations outside this band are damped out. If a certain oscillation exists in the original series, application of the correct filter will in theory produce a resultant series with a well-marked amplitude, while if the specified oscillation is absent a correspondingly featureless series will result. A filter with a limited number of terms cannot achieve this aim perfectly, but the set of 13 filters used does provide a considerable degree of separation of the various component oscillations of the series into bands with peak periods at 24, 24/2, 24/3, 24/4, . . . 24/12 months.

The curves for Canton Island and Singapore are shown in Figures 1 and 2, and Table I gives the percentage of the total variance or variability covered by each oscillation. At both Singapore and Canton Island by far the largest amount of the variability can be attributed to oscillation with a period around 24 months. Important contributions come from the 12-month wave, with decreasing contribution from shorter wavelength, everything less than 6 months being effectively 'noise', that is small-scale variations including observational errors.

TABLE I—VARIANCES OF FILTERED SERIES OF ZONAL WINDS FOR SINGAPORE AND CANTON ISLAND

Peak period of oscillation (*months*)	Effective range of period (*months*)	Percentage of total variance occurring in each band	
		Singapore	Canton Island
Long Period	>48	4·3	3·9
24	48–16	58·8	77·3
12	16·0–9·6	12·3	10·0
8	9·6–6·9	8·9	3·1
6	6·9–5·3	6·0	2·5
24/5	5·3–4·4	2·9	1·1
4	4·4–3·7	2·2	0·8
24/7	3·7–3·2	0·9	0·3
3	3·2–2·8	1·5	0·3
8/3	2·8–2·5	0·8	0·2
24/10	2·5–2·3	0·4	0·2
24/11	2·3–2·1	0·7	0·2
2	2·1–2·0	0·7	0·1

Figures 1 and 2 confirm this; the amplitudes of the 24-month waves are much larger than those of the other component waves. There is some indication that

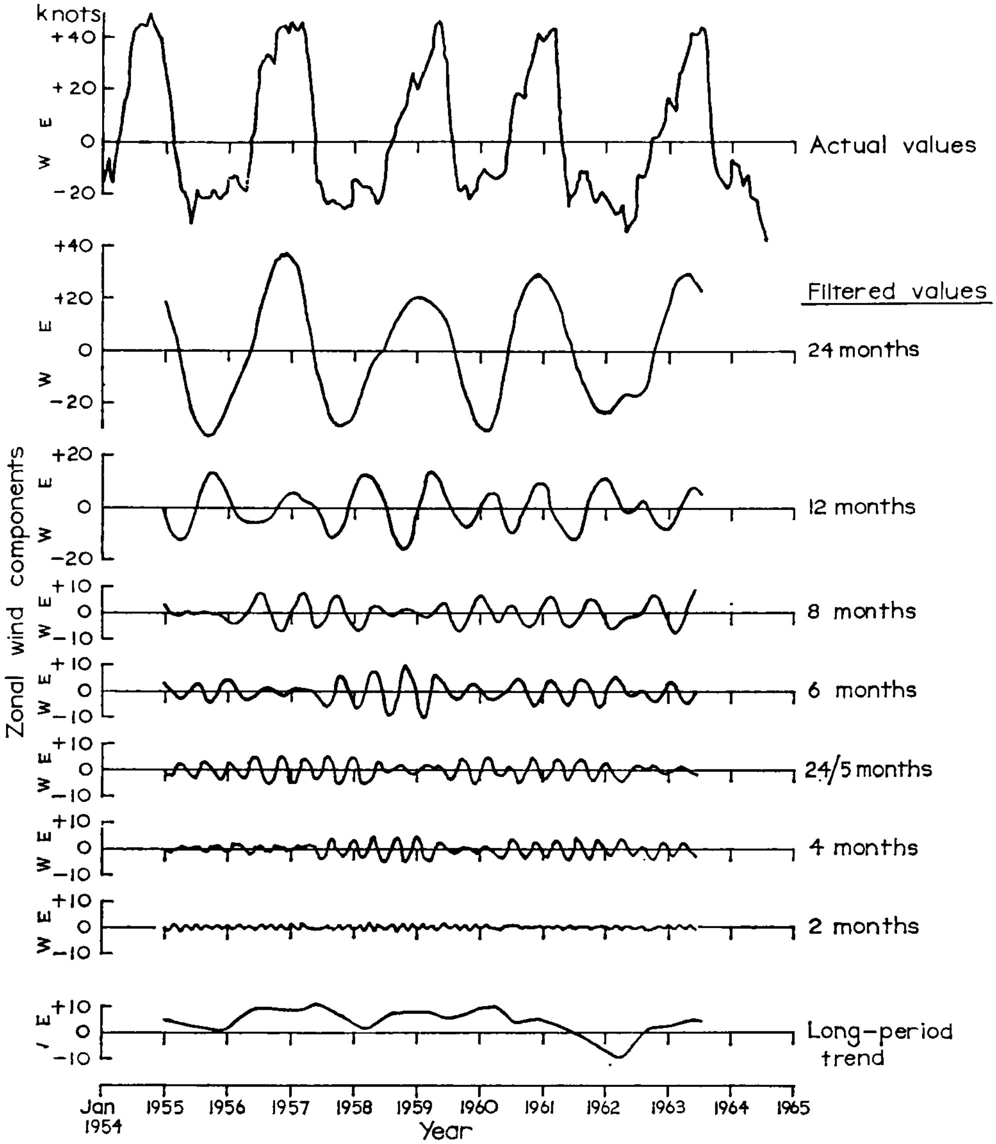

FIGURE 1—ZONAL WIND COMPONENTS AT 50 MB (68,000 FEET) AT CANTON ISLAND FILTERED TO SHOW OSCILLATIONS WITH VARIOUS PERIODS

Canton Island is 02°46′S, 171°43′W.

the regularity of the oscillations was upset in the spring of 1962 and that some slight change of phase took place. At this time the long-term trend shows a swing to westerly from its general easterly direction. It will be interesting to see how the oscillations settle down during subsequent cycles.

Also apparent from Figure 2 is the notable oscillation in the 6-month wave from 1958–60 which is quite insignificant before and after this period. This is quite a good example of the way spurious cycles so often come and go in meteorological series.

Since the data for Singapore are related to a lower height than the data for Canton Island, the amplitudes of the Singapore waves are on the whole smaller than those for Canton Island. The height discrepancy also explains the lag of the

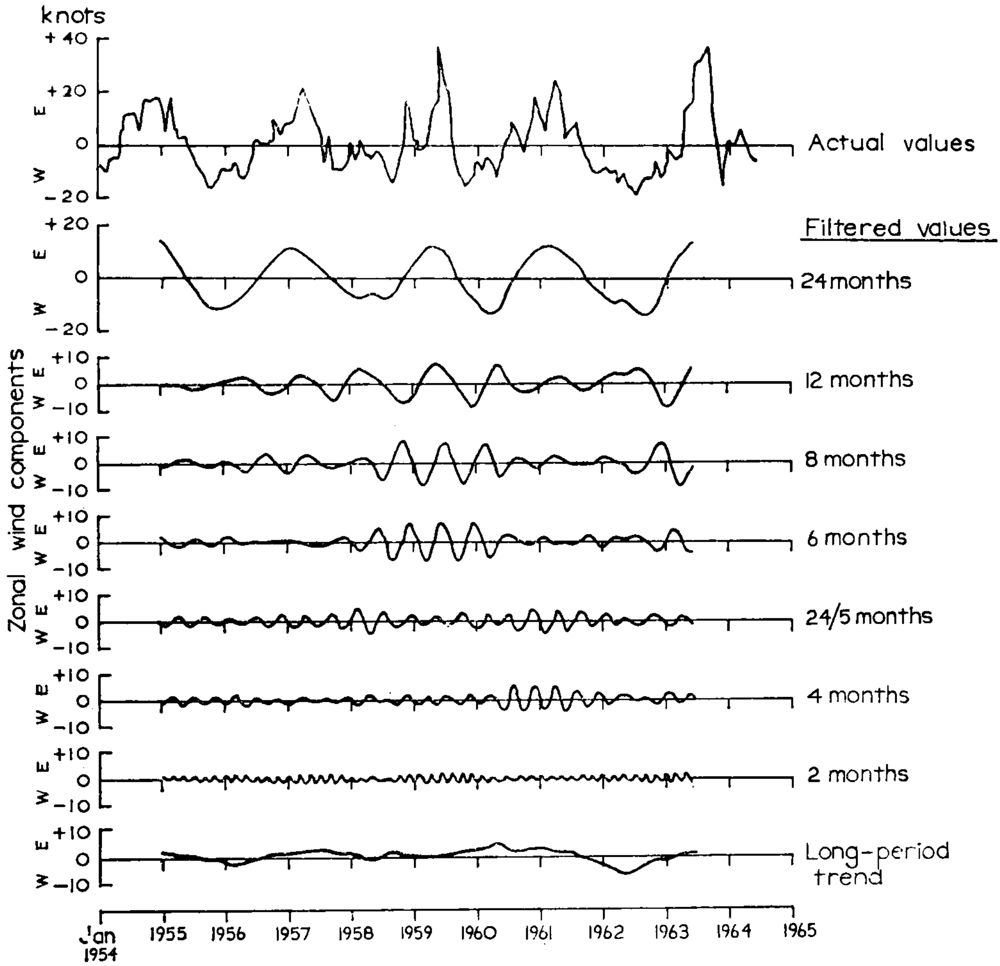

FIGURE 2—ZONAL WIND COMPONENTS AT 60,000 FEET AT SINGAPORE FILTERED TO SHOW OSCILLATIONS WITH VARIOUS PERIODS

Singapore is 01°20′N, 103°53′E.

peaks and troughs of the Singapore oscillation behind those of the Canton Island oscillation, especially for the 24-month wave (this lag was pointed out and investigated by Veryard and Ebdon[2]).

However, although a lag of about 3 months occurs in the 24-month wave, the lag steadily decreases as the period of oscillation decreases and is only half a month for the 4-month wave, while there is no lag discernible for the 2-month wave. These lags are set out in Table II.

TABLE II—TIME LAG OF FILTERED SERIES OF ZONAL WINDS FOR SINGAPORE BEHIND THOSE FOR CANTON ISLAND

Period of oscillation (*months*)	Time lag (Canton Island leads Singapore (*months*)
Long period	3
24	3
12	2
8	1½
6	1
24/5	½
4	½
2	Nil

The set of filters used in this investigation has the property that the sum of the filtered components gives the original wind. It is probably easier to extrapolate the filtered curves rather than the original series and hence to obtain a forecast of the monthly mean zonal winds. In practice, since the contribution of waves with periods less than 8 months is relatively small, only the longer-period oscillations need to be extrapolated, and the sum of the components of these should give a reasonable prediction of the wind. The process of extrapolation is, however, made more difficult by the fact that filtered series necessarily end 12 months prior to the most recent observation, and in order to forecast 2 months ahead the curves must be extrapolated for 14 months.

Westcott,[3] Shapiro and Ward,[4] and others have sought to relate the fluctuation of stratospheric winds to solar radiation and have tried to demonstrate the existence of a 26-month cycle of sunspot numbers. If such a cycle exists it should be revealed by the filtering technique which was therefore applied to the monthly mean sunspot numbers for Zürich for 1749 to 1964. The wave band with peak period at 24 months accounts for only about 2 per cent of the total variance, but it is apparent from Figure 3, which shows plots for three 30-year sections of

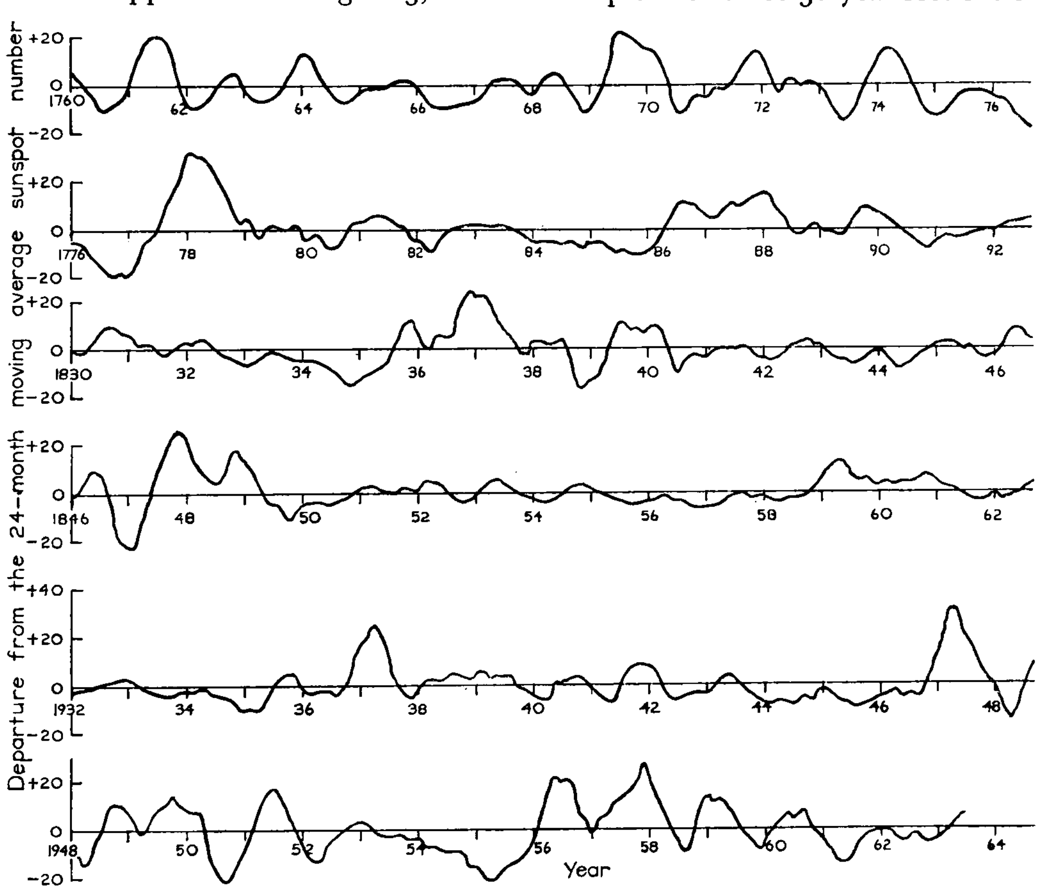

FIGURE 3—ZÜRICH SUNSPOT NUMBERS FILTERED TO SHOW 24-MONTH OSCILLATION AS DEPARTURES FROM THE 24-MONTH MOVING AVERAGE

the results, that there is no outstanding or maintained 24- or 26-month oscillation. We must conclude, therefore, that no regular biennial oscillation of sunspot numbers exists and if there is a connexion between sunspot numbers and tropical stratospheric winds it is by no means a simple one.

Appendix

Calculated filter terms for various bands with given peak periods (the table entries must be multiplied by 10^{-4}*)*

If the terms of a filter are represented by

$$f_1, f_2, f_3 \ldots f_i \ldots f_{13}$$

where f_i is the ith term of the filter, and successive monthly zonal winds are represented by $V_{t-12}, V_{t-11} \ldots V_t \ldots V_{t+11}, V_{t+12}$, where V_t is the zonal wind at time t, then the filtered value of the zonal wind at time t is given by

$$f_{13}V_t + \sum_{i=1}^{i=12} f_i \left(V_{t-13+i} + V_{t+13-i}\right)$$

Peak periods of oscillation (*months*)	f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8	f_9	f_{10}	f_{11}	f_{12}	f_{13}
long-period	+208	+417	+417	+417	+417	+417	+417	+417	+417	+417	+417	+417	+417
24	-417	-805	-722	-589	-417	-216	000	+216	+417	+589	+722	+805	+833
12	+417	+722	+417	000	-417	-722	-833	-722	-417	000	+417	+722	+833
8	-417	-589	000	+589	+833	+589	000	-589	-833	-589	000	+589	+833
6	+417	+417	-417	-833	-417	+417	+833	+417	-417	-833	-417	+417	+833
24/5	-417	-216	+722	+589	-417	-805	000	+805	+417	-589	-722	+216	+833
4	+417	000	-833	000	+833	000	-833	000	+833	000	-833	000	+833
24/7	-417	+216	+722	-589	-417	+805	000	-805	+417	+589	-722	-216	+833
3	+417	-417	-417	+833	-417	-417	+833	-417	-417	+833	-417	-417	+833
8/3	-417	+589	000	-589	+833	-589	000	+589	-833	+589	000	-589	+833
24/10	+417	-722	+417	000	-417	+722	-833	+722	-417	000	+417	-722	+833
24/11	-417	+805	-722	+589	-417	+216	000	-216	+417	-589	+722	-805	+833
2	+208	-417	+417	-417	+417	-417	+417	-417	+417	-417	+417	-417	+417

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551.521:061.3

THE LENINGRAD RADIATION SYMPOSIUM, 1964

This Symposium, held from 6–12 August, was mainly organized by the Radiation Commission of the International Association of Meteorology and Atmospheric Physics (IAMAP) of the International Union of Geodesy and Geophysics (UGGI) with the World Meteorological Organization (WMO) and the Committee for Space Research of the International Council of Scientific Unions as co-sponsors. There was representation of the three concerned WMO working groups, those on atmospheric radiation (of the Commission of Aerology), on radiation instruments and observations for general use, and on special radiation instruments and observations (of the Commission of Instruments and Methods of Observation), and of the International Society for Biometeorology.

The Radiation Commission, the oldest in IAMAP, holds a Symposium about every three years, and increasing interest has been shown in the subject in recent times. It is a far cry from the first meeting in Switzerland in 1912, at which only three members and one guest took part, to the 1959 meeting at Oxford[1] with some 76 participants from 19 countries, to the 1961 Vienna meeting with 95 participants from 22 countries and on to the vast increase at the Leningrad Symposium to some 300 participants from 28 countries. This recent surge of interest began with a large increase in radiation stations during the International Geophysical Year (IGY), leading to effective global studies, and has been further stimulated by upper air and satellite observations and the growing possibility of introducing radiation computations into numerical forecasting schemes.

It was most appropriate that the present Symposium took place in Leningrad where Professor Budyko, Director of the Main Geophysical Observatory, prepared his famous radiation atlas,[2] and where the widely appreciated theoretical and experimental radiation researches of the Institute of Atmospheric Physics at the University—under the direction of Professor Kondratiev—are carried out.

The local arrangements were made by the Soviet Academy of Sciences which supplied a most adequate secretariat and a large assembly hall, in a former palace, for the meetings (this hall was where the original Duma, or Czar's, Parliament was held—there was an interesting glimpse of the building in its original use in the recent television series on the First World War). Most of the abstracts of the papers were available for distribution at the beginning of the Symposium and others were distributed as the Symposium proceeded.

The Selection Committee had the very difficult task of cutting down the large number of papers submitted and of the total of 144 no less than 65 had to be presented by title only. The President of the Commission, for the first time, decided, because of the abundance of papers, not to give the usual President's scientific address. The accepted papers were divided into two classes, those 'invited' being given in the mornings with some half an hour for presentation; the authors of the afternoon 'contributed' papers were allotted only 10–15 minutes. The two main languages were English and Russian and excellent simultaneous translation facilities were provided. Owing to the large number of papers the official discussions were inevitably too hurried but there was ample opportunity, which was taken by all concerned, for discussions outside the set periods, although the working days were long. (Sunday, the only free day, was agreeably occupied by a river excursion to a historic palace; there was a splendid evening reception, a most pleasant concert and, immediately the Symposium finished, organized tours in and around the city, including visits to scientific institutions.)

There were six separate sections, a day being devoted to each section, the pattern being that some 4–5 invited papers were given in the morning and some 5–10 contributed papers in the afternoon. There were only two cases of overlap of sections which are mentioned below. Each section had a convener who opened the discussion, either with a short review or a relevant paper. No detailed publication of the papers is to be attempted by the Symposium organizers, as many will no doubt find their way into the literature, but it is intended that the programme, titles and abstracts of the papers be published in a special UGGI Monograph. Some notes follow on the problems discussed in the various sections.

Theory of radiative transfer in planetary atmospheres.—Professor Sekera (University of California) spoke on the recent developments in attaining a realistic model of a planetary atmosphere, namely the solutions in which multiple scattering and the state of polarization of diffuse radiation are taken fully into consideration. The work is an extension of Chandrasekhar's[3] analysis and provides a rigorous and computationally feasible method of solution of such general problems as the effect of ozone absorption on scattering in the near ultra-violet, the broadening of absorption lines due to scattering, the effect of scattering on atmospheric emission, radiative transfer in a real atmosphere in the near infra-red (dust particle scattering being taken into account) and radiative transfer in a turbid atmosphere or in a cloud layer. G. V. Rosenberg (Institute of Physics of the Atmosphere, Moscow), followed by outlining the Russian work on this difficult problem; approximate solutions of the transfer equations had been obtained with certain models and the influence of different types of clouds had been considered. Further speakers from the U.S.S.R. and U.S.A. outlined other methods used in similar computations. At the end of the session there was a series of papers on measurements and computations in turbid atmospheres; the absorption, in addition to the scattering, of radiation by atmospheric aerosols was emphasized, notably by Sekihara (Meteorological Research Institute, Tokyo).

Infra-red spectroscopy of the atmosphere.—Like the first section, this section was mainly concerned with theoretical studies but there was also some comparison with the experimental data in which the discrepancies showed there was still much to learn in the subject. W. S. Benedict (Johns Hopkins University, Baltimore) opened with a review of the current position regarding several problems basic to the theoretical interpretation of the detailed structure of molecular bands in the atmosphere. He also described the work on the study of the solar spectrum using a spectrograph, of the University of Liège, installed at the International Scientific Station of the Jungfraujoch (Switzerland), elevation 3580 metres. Subsequent speakers (from U.S.A., U.S.S.R., U.K., Germany, Canada and France) discussed various aspects of the subject and it was notable that here, as well as in a paper given in Section 1, the atmospheres of the planets Venus and Mars were being considered in some detail.

Radiation climatology.—Professor Budyko opened with a paper on the study of the solar radiation régime on the surface of the earth. He mentioned the useful increase in radiation stations in recent years and the work done leading to the preparation of his atlas and of more detailed maps available at the Main Geophysical Observatory, but stressed the fact that the world network is still very uneven in that the oceans and vast land areas are not covered. Radiation climatological data were used for solving different applied problems, such as evaporation from a land surface, the rate of photosynthesis of vegetation and the thermal state of man in the open air—leading to deduction of correct clothing requirements. There were detailed radiation climatology studies from Sweden (Ångström, 'Atmospheric turbidity as a parameter within radiation climatology'); from the U.S.A. (Bennett, 'A contribution to the insolation climatology of the United States'); from the U.S.S.R. (Pivarova, 'Radiation climate of the U.S.S.R.'; Rusin and Marschunova, 'The radiation balance of Arctic and Antarctic'; Barteneva and Poliakova, 'Study of extinction and scattering of light in hazes, fogs and precipitation'; from Germany (Barg, 'The space and time distribution of radiation and radiation balance at sea level'); and from Japan (Yamamoto and Tanaka, 'Aerosol climatology as estimated from direct solar radiation measurements').

A simultaneous afternoon session of this section, which the writer was unable to attend, was concerned with radiation observations from satellites and seven papers were presented on this subject, mainly on the evaluation of the radiation measurements made by means of the TIROS satellites.

Radiation problems as related to atmospheric dynamics and the general circulation.— Professor Goody (Harvard University) introduced the subject by stating that up to quite recently people were deterred, by its complexity, from attempting to solve the problem of relating radiative transfer to the atmospheric circulation. It was thus decided that the Commission for Radiation and the Commission for Dynamical Meteorology of IAMAP should combine to discuss the problem here. Rakipova and Shneerov (Main Geophysical Observatory, Leningrad) discussed past attempts and a present attempt to take radiation heat transfer into account in problems of the theory of climate and numerical prediction. Such factors as the selective absorption of long-wave and short-wave radiation, the latitudinal distribution of the albedo of the earth–atmosphere system and the amount of radiation absorber (water vapour and carbon dioxide) were taken into consideration. This approach to the problem allows not only a closer approximation to the actual distribution of temperature but also to correct values of radiation heat fluxes. Several authors were quoted as using balance ratios to allow the more precise calculation of radiation heat transfer taking cloudiness into account: experimental calculations (with a computer) show that this factor makes short-period forecasting more successful. The other papers presented in the morning session, 'A numerical integration of the general circulation of the atmosphere with the explicit calculation of radiative transfer', 'Some aspects of the role of heat sources in atmospheric dynamics' and 'The diurnal wave in a grey stratified atmosphere: a radiative-conductive model' considered the main subject in some detail, but these papers and the discussion on them indicated that there was much work still to be done before a synoptic tool was fully developed. In the afternoon session the papers had particular reference to the relation between radiative transfer and convection.

There was a simultaneous afternoon session on another day which the writer was unable to attend; four papers were presented with the titles, 'Radiative heating and motions in the mesosphere', 'The influence of photochemistry and radiative transfer on stratospheric dynamics', 'Radiative heat exchange as a dissipative factor in the atmosphere' and 'The decay of small temperature perturbations by thermal radiation in the atmosphere'.

Surface and network instrumentation.—The co-conveners for this section, A. J. Drummond (U.S.A.) and Dr. W. D. Yanishevsky (U.S.S.R.), opened the session by giving separate papers, Drummond on 'A review of new techniques and associated instrumentation for the measurement of component and net flux solar and terrestrial radiation' and Yanishevsky on 'The principles of radiation instruments for network use in the U.S.S.R.'. Drummond, in a general opening statement, mentioned the great improvement in instruments which has been helped by the demand for accurate instruments for space measurements. There is more emphasis now on the international comparison of instruments. Balance meters were first compared at Hamburg eight years ago and another international comparison, on a much wider scale, is now beginning. Solarimeters last compared internationally at Davos in 1959 were being compared again there after this Symposium. His paper reviewed a number of new scientific approaches which have been introduced, with the relevant instrumentation, by the Eppley research team in the post-IGY period, notably in regard to the improvement of thermopile radiometers particularly for high-speed response and for more accurate illumination measurements, to the provision of precision filters to isolate specific spectral bandwidths, and to the more accurate determination of long-wave exchange. Yanishevsky gave a full and most interesting account of the development of Russian radiation instruments in the past, with which he himself had been concerned for many years, and of the plans for the future. L. Jacobs (U.K.) in describing 'The operation of a network of shipborne radiation instruments' summarized the results from some of the solar radiation measurements from the British Ocean Weather Ships in the North Atlantic, which were in reasonable agreement with the estimates made in the Russian *Atlas of heat balance.* He explained the improvement of instrumentation and mountings since the IGY period and described how the scheme was being extended to British ships engaged on voyages all over the world; six ships had already been equipped with pen recorders, and a total of some 20 ships was planned with magnetic tape recording for easy analysis of the results. The Meteorological Office data logging equipment, now in use at most British radiation recording stations, and to be installed in the four Ocean Weather Ships, was briefly mentioned. Other maritime nations were urged to start similar schemes for the making of routine radiation recordings at sea to obtain essential climatological information.

Professor Kondratiev followed by describing a complex of spectral apparatus for the experimental investigation of the short-wave radiation field in the earth's atmosphere which is to measure the spectral fluxes of global, scattered and direct radiation, the angular distribution of spectral sky brightness and the spectral albedo of the surface. Preliminary measurements have been made at ground level and aircraft observations are planned; the experimental results are to be compared with the theoretical calculations.

In the afternoon session papers were given on the network instrumentation and techniques in India (Mani) on the calibration and comparison of instruments (both in the U.S.S.R. and the U.S.A.), on a multichannel measuring and integrating equipment (Paulsen, Norway), on the measurement of sky and surface radiances by quantitative photography (Kovsky, U.S.A.) and on scattered sky radiation, its measurement, correction and application (N. Robinson, Israel).

Experimental investigations of the radiation field in the free atmosphere.—In this section, the measurements obtained by instruments borne aloft by radiosonde, aircraft and sounding rockets were described. Professor Kondratiev opened the discussion with a paper on 'Balloon investigation of radiation fluxes in the free atmosphere' and was followed by Bargman (U.S.A.) describing the infra-red and visible radiation measurements by radiometer, spectrophotometer and interferometer on high-altitude balloon flights at 35-km altitude. These and later speakers emphasized that the instrumental observations obtained by ascents from below are to be supplemented by observations from instruments on satellites. Two of the papers gave the principles of projected methods of the determination of cloud-top altitudes by radiation measurements from a satellite. The wide range of subjects discussed is illustrated by the titles of some further papers, 'Measurements of ozone production by solar ultra-violet radiation', 'Measurements of infra-red radiative flux in the upper air over Poona', 'Chemical instability of the stratosphere' and 'Optical probing (by searchlight) in the U.S.A., instrumentation and results'.

L. JACOBS

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2. BUDYKO, M. I.; Atlas of the heat balance of the earth. Akad. Nauk U.S.S.R., Main Geophysical Observatory, Moscow, 1963.
3. CHANDRASEKHAR, S.; Radiative transfer. Oxford, Oxford University Press, 1950.

REVIEWS

Probleme der Gewitterforschung, 1. *Das Gewitter in heutiger Sicht* by Dr. Hans Israël. $6\frac{1}{2}$ in × $6\frac{1}{4}$ in, pp. 60, *illus.*, Westdeutscher Verlag, 567 Opladen/Rhld, Ophovener Strasse 1–3, 1964. Price: DM 29.50.

This 60-page monograph is the first of a series on the problems of thunderstorm research. Written in German, it is a general review of the present state of knowledge. At first sight it appears to be commendably up to date: of the 134 references cited the latest is to be published in 1965 (the earliest paper quoted was written by Faraday in 1845).

This is not a book for the general reader; it omits almost all the fascinating background of the eighteenth century work. After an introductory paragraph, which whets the appetite with a tit-bit about d'Alibard's proof of the identity of lightning and an electric spark in 1752, there is nothing. Benjamin Franklin who proposed the experiment d'Alibard carried out and who made his famous kite experiment in the same year is not mentioned.

Neither is this a book for the research worker, nor the meteorological physicist. As an account of the dynamics, energy transformations and electrical processes of storms it is almost entirely descriptive. Only rarely are numerical values given.

The section on dynamics consists mostly of a summary of the results of the post-war American 'Thunderstorm Project' with no mention of later work on severe storms in Britain and the United States.

In the section on energy transformation the author concludes that in a typical storm the rate of transformation into electrical energy depends on, and is an order of magnitude less than the 60,000 megawatts obtained from, the release of latent heat.

The annual number of days with thunderstorms is shown on a chart based on reports for the year 1953 and 1956. The northern and southern limits of storms are roughly at the edge of the pack-ice. The isopleth with the highest value is for 180 days/year, around Lake Victoria. Java is shown with only 100 days/year. This is so much less than the average 322 days/year which occurred in Buitenzorg (now Bogor) in the years 1916–19 and which gives the island its place in the record books, that we might have expected some comment from the author but there is no mention even of this record value.

The section on electrification processes is the most comprehensive one. Processes which occur in clouds and which laboratory work has shown to generate charge are diligently attributed to their investigators. The author concludes that no process is likely to be the only significant one and that the main problem now is to determine the relative importance of the various processes, but he does not assess each of them quantitively. Reports of tropical thunderstorms generated in clouds containing ice are not discussed.

Many of the deficiencies of this book may arise because it has been judged alone. As an introduction, when the whole series is available, it may have some value. By itself it covers roughly the ground that is covered on thunderstorms on an initial course of lectures for forecasters. More comprehensive and more interesting texts at the same level are already available in English.

S. G. CORNFORD

Gaseous composition of the atmosphere and its analysis, by B. A. Mirtov (translated from the Russian). 9¾ in × 6¾ in, pp. 209, *illus.*, Israel Program for Scientific Translations (distributed by Oldbourne Press, 1–5, Portpool Lane, London, E.C.1), 1964. Price: 90*s*.

This book is primarily concerned with instrumental technique, as used both in the USSR and elsewhere. Some results are given and these are summed up in a six-page 'Conclusions'. An even shorter summary is possible:

Up to 100 km the atmosphere is thoroughly mixed.

Above 100 km dissociation and gravitational separation become important but "final conclusions . . . must await new experimental data".

In addition some sketchy data are given about the occurrence of ionization.

There is no discussion of water vapour at all. Ozone is discussed in an Appendix, written by G. S. Ivanov-Kholodnyi. This is a 19-page section followed by 169 references; but the discussion is superficial and, in places, misleading (e.g. the statement that "One must regard the small fluctuations in the overall ozone content, which are sometimes observed from day to day, with a certain suspicion"; and "The discussions as to the justification for using the inversion (Umkehr) effect can thus be regarded as closed, and the method may be assumed to be both reliable and useful").

The translation appears to be good. There is no index.

R. FRITH

Allgemeine Klimageographie, by J. Blüthgen. 10¼ in×7 in, pp. xiv+408, *illus.*, Walter de Gruyter & Co., Genthiner Strasse 13, Berlin 30, 1964. Price: 48 DM.

In his treatment of climate, Aristotle used the term 'meteorology' (study of things on high) but there has been a tendency to reserve 'meteorology' as a term to denote the study of weather processes. There has also been a tendency to regard climatology as the collection and classification of climatic data, although attempts by Poseidonios to relate climate to the sun's inclination are evidence of an informed use of the word 'klima' and of an early study of process. The re-introduction of the study of process within climatology has led to the development of the term dynamical climatology, a term clear in meaning but nevertheless not without suspicion of tautology.

A similar obscurity is attached to the relations between climatology and geography. The original use of yearly isotherms in the designation of climatic areas was due to Alexander von Humboldt, one of the founders of modern geography. The collection and plotting of climatic data became part of the content of geography. The author of 'Allgemeine Klimageographie' suggests that in fact climatology became part of geography and remained so despite the growth of synoptic meteorology. Now, however, with the growth of knowledge of the upper atmosphere, climatology must be regarded as an independent discipline, and only part of climatology is of immediate significance to geographers. For this part he proposes the term 'Klimageographie'. Blüthgen does not suggest that this absolves the geographer from a study of processes, indeed he advocates a genetic approach, but that the strongest emphasis should be placed on the phenomena most immediately affecting the earth's surface. Although the adequacy of this approach may be questioned, the content of this book, which forms part of a series with the aim of providing an adequate background in systematic geography at university level, is in accord with this definition. University geographers in this country will nevertheless find the treatment of such themes as stability and atmospheric circulation over-simplified and not sufficiently mathematical. For geographers specializing in climatology or exploring the former bounds between the two disciplines the treatment is correspondingly more inadequate, although giving a readable account of much modern research.

The work is divided into nine main sections, of which the first is an account of the historical development of climatology. The second section, occupying half the book, is a description of climatic elements, subdivided conventionally into temperature, water vapour, pressure and winds. The presentation is clear and well illustrated and the material up to date, but it is revealing of the approach that the section on rainfall deals only briefly with the problems of coalescence, and the section on 'fall' winds makes only brief mention of lapse rates. The third section deals with synoptic 'Klimageographie' and English readers will find the continental emphasis stimulating. The general circulation of the atmosphere is dealt with in section four. Here too, the approach is generally non-mathematical but the description takes account of recent work on the circulation of the atmosphere by Rossby, Reihl, Sutcliffe and Flohn. Climatic types are dealt with in section five; climatic change forms the subject matter of section six and climatic classification of section seven. The treatment, drawing upon German research, will appear fresh to many English readers and these sections are to be considered the most stimulating parts of the book.

Sections eight and nine deal briefly with attempts at climatic control and the mitigation of climatic effects by man, and with acclimatization. A good bibliography is given for each section. The works consulted are mainly of German language, but there are also French, American and British references.

E. M. YATES

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NOTES AND NEWS

Halo display at Bracknell, Berkshire, on 11 May 1965

I first noticed bright mock suns with tails (part of the mock-sun ring) to the left and right of the sun (about 22° away) at 1745 GMT; the one to the left was particularly brilliantly coloured. These persisted and at times the entire upper half of the 22° halo was also visible, showing red near the sun and orange to yellow outside. At 1840 GMT two brilliant arcs appeared (arcs CD and CE in Figure 1); they were flexed with their concave side towards the sun like the horns of a ram (see Plate II). It is noted in the *Observer's Handbook** that

*London, Meteorological Office. Observer's Handbook. 2nd edn. London, HMSO, 1956, p.130.

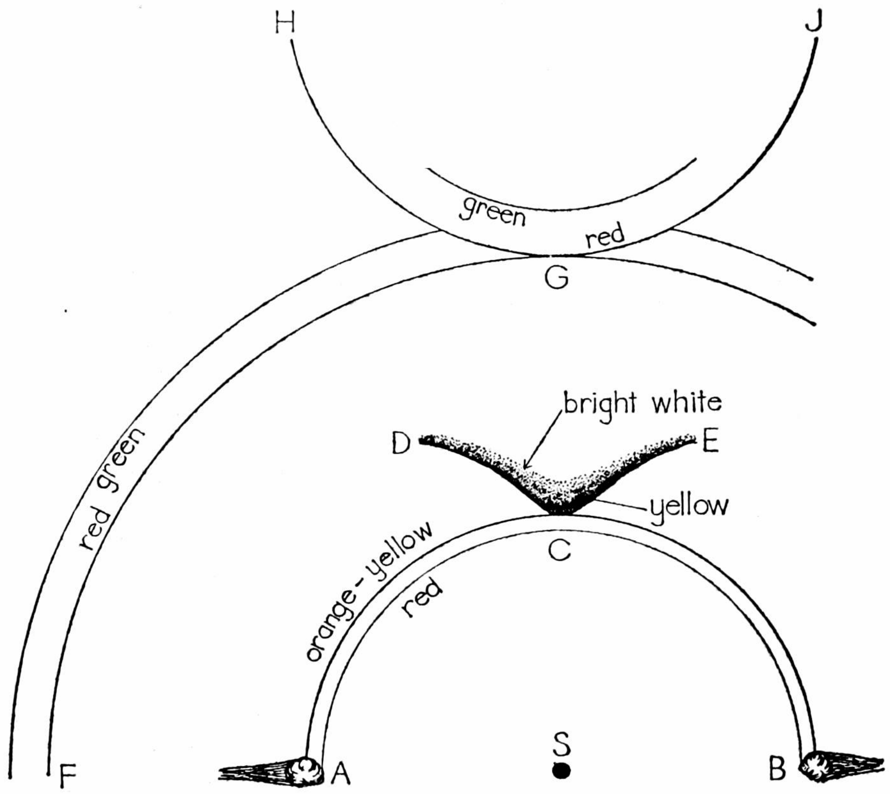


FIGURE 1—DIAGRAMMATIC SKETCH OF THE SOLAR HALO PHENOMENA SEEN AT BRACKNELL ON 11 MAY 1965

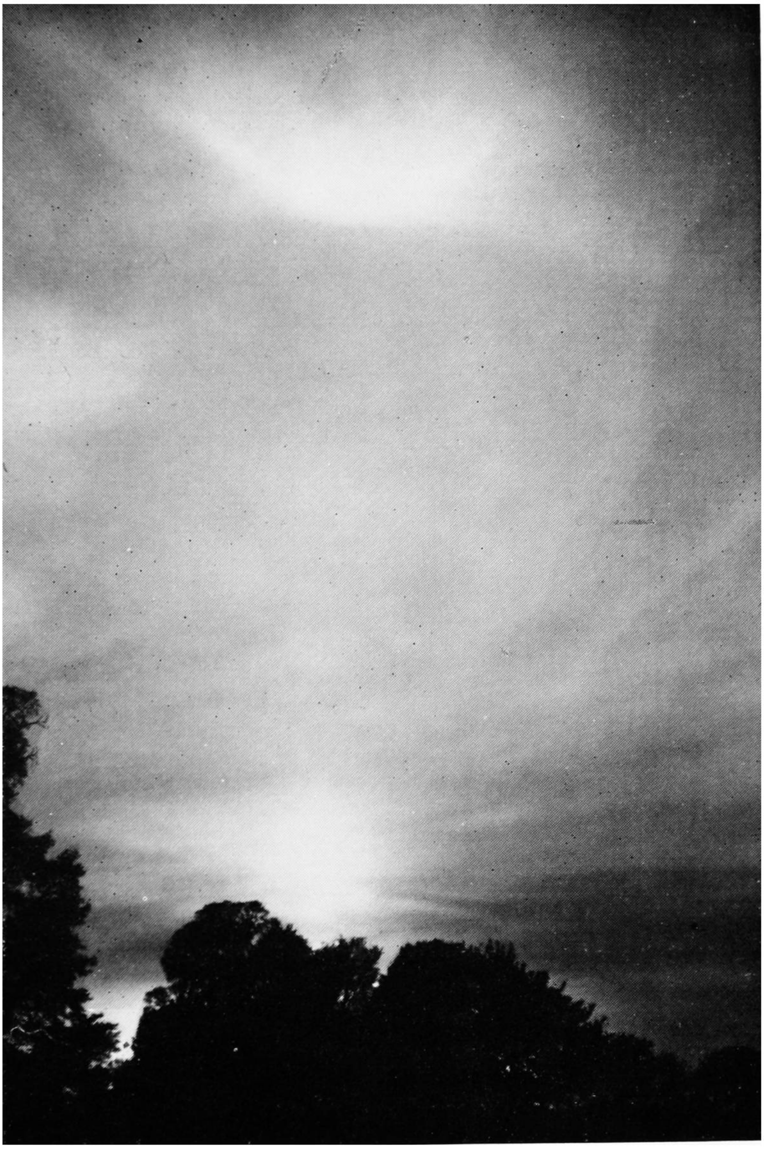
A,B	Mock suns	S	Sun
CD, CE,	Arcs of contact	HGJ	Circumzenithal arc
ACB	22° halo		
FG	46° halo		

when the sun is low the arcs of upper contact appear with their convex sides turned towards the sun. By 1850 a portion of the 46° halo (FG in Figure 1) became visible showing a pure red on the sun side and a broad green belt on the outside; a few minutes later a portion of the circumzenithal arc appeared, in contact with the 46° halo and similarly coloured. By 1910 GMT all had faded except one brilliantly coloured mock sun (B in Figure 1) but at 1935 the bright arcs of contact (CD and CE) again appeared for a few minutes.

R. K. PILSBURY

AWARD

We note with pleasure that the International Meteorological Organization Prize for outstanding work in meteorology and international collaboration, has been awarded for 1965 to Professor S. Petterssen from the United States of America by the Executive Committee of the World Meteorological Organization during its 17th session.



Photograph by B. D. Mason

PLATE II—SOLAR HALO PHENOMENA SEEN AT BRACKNELL ON 11 MAY 1965

The arcs of upper contact are shown as CD and CE on Figure 1 on page 315.

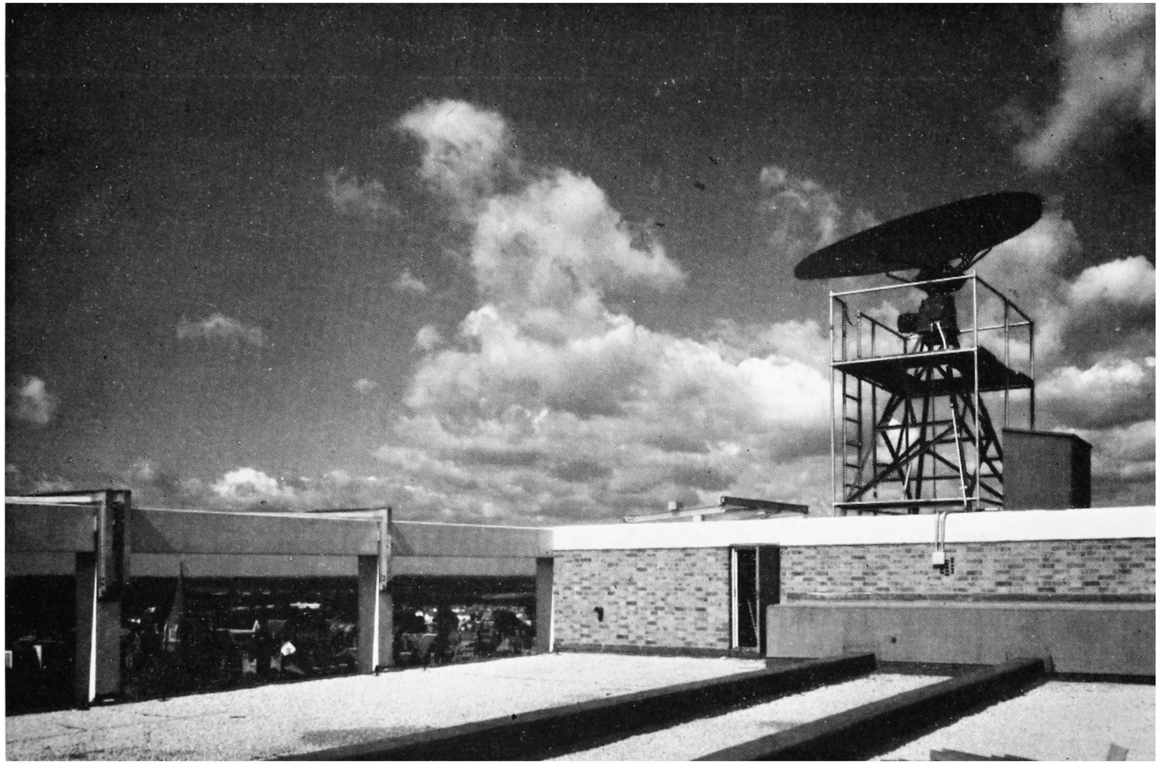


PLATE III—WEATHER RADAR AERIAL ON THE ROOF OF THE METEOROLOGICAL OFFICE HEADQUARTERS AT BRACKNELL

OFFICIAL PUBLICATION

SCIENTIFIC PAPER

No. 21–*Estimation of rainfall using radar–a critical review*, by T. W. Harrold, B.Sc., D.I.C.

This publication contains a critical review of the possibilities of using a weather radar to measure rainfall over an area, such as a river catchment, as it falls. Two methods are discussed.

By relating the power reflected from the rain to the rate of rainfall it is possible to estimate the rainfall amount, the probable error in such an estimate being 25 per cent. To achieve this accuracy a narrow beam width and a wavelength greater than 5 cm are necessary. In winter in the United Kingdom the error will be larger since the beam passes above the rain into snow at larger ranges. The circuitry required to provide automatic measurements is discussed.

An alternative method is to measure the attenuation of radiation, of wavelength about 1 cm, and to relate this to the rate of rainfall. Although theoretically more accurate, practical considerations, such as the size of a reflector required at larger ranges, make this a less satisfactory method of estimating rainfall compared with measuring the reflected power.