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MEMORIAL TABLETS AT KEW OBSERVATORY

In 1950 the late Mr. R. S. Whipple approached Sir Nelson Johnson with the offer to provide at Kew Observatory some memorial to his father and brother and to the other Superintendents of the Observatory with whom his family had been linked. Sir Nelson, in agreeing, suggested that there should also be some separate memento of Mr. Whipple's grandfather, Robert Beckley, mechanical assistant at the Observatory for 20 years.

Preparation of the tablets was entrusted to Mr. Ernest Gillick; he died before the work was complete but it was taken up by Mrs. M. Gillick, known for her design on the new coinage. The tablets are of a Derbyshire marble, the larger one bears the Royal Arms of H.M. King George III, in low relief, gilt, with the wording

His Majesty King George III built this Observatory
primarily to observe the transit of Venus in the year
1769

KING'S OBSERVERS

1769 Stephen Charles Triboudet Demainbray
1782 Stephen George Francis Triboudet Demainbray

SUPERINTENDENTS

1842 Sir Francis Ronalds, F.R.S.
1852 John Welsh, F.R.S.
1859 Balfour Stewart, F.R.S.
1871 Samuel Jeffrey
1876 George Mathews Whipple
1893 Charles Chree, F.R.S.
1925 Francis John Welsh Whipple
1939 James Martin Stagg
1939 Sir George Simpson, F.R.S.

The smaller tablet has the inscription

To Robert Beckley Assistant in this Observatory 1853–72. He invented the recording anemometer and the rain-gauge bearing his name + Dedicated in 1952 by his grandson Robert Stewart Whipple

The tablets are placed in the south octagon room at the Observatory.

The memorials were unveiled by Sir George Simpson on July 21, 1954. Mr. R. S. Whipple died early this year, and the tablets were presented to the

Observatory by his son, Mr. G. A. Whipple, in the presence of Mrs. R. S. Whipple and members of her family, Mrs. Gillick, the Director of the Meteorologial Office, and a few former colleagues of Dr. F. J. W. Whipple. Mr. Whipple gave some details of the family connexion with the Observatory, which is even closer than appears from the wording of the tablets. G. M. Whipple entered as an assistant under his father's close friend John Welsh (at a salary of eight shillings a week) and served under Balfour Stewart and Samuel Jeffrey before becoming Superintendent, and R. S. Whipple, a godson of Balfour Stewart, was himself on the Observatory staff for three years under Charles Chree.

Sir George Simpson then unveiled the memorial, and outlined the history of the Observatory as it came successively under the Royal Household, the British Association, the Royal Society, the National Physical Laboratory and the Meteorological Office. He dwelt on the remarkable foresight of the British Association Committee which in 1842 defined the "Objects of the Observatory" to include the following: complete observations of meteorology, terrestrial magnetism, and atmospheric electricity—eye observations to be replaced by self-recording instruments—balloon observations to be made, in particular "a method to be devised for telegraphing the indications of meteorological instruments carried up in balloons or in kites to an observer at the earth's surface"—new methods and instruments to be studied and developed—scientific instruments to be compared with standards kept by the Observatory. Sir George showed how, through the years, all these subjects had received attention and been notably advanced at Kew, though the radio-sonde, called for in 1842, had to wait almost a century for its realization. Sir George spoke particularly of the work of Welsh and Beckley in the designing and making of instruments, and of Stewart and Beckley in equipping the seven meteorological observatories which began a continuous photographic record in 1869.

Dr. Sutton, accepting the tablets on behalf of the Meteorological Office, spoke of his pleasure in seeing a unique family connexion commemorated.

WORLD METEOROLOGICAL ORGANIZATION

Fifth Session of the Executive Committee

By O. G. SUTTON, D.Sc., F.R.S.

The Executive Committee of the World Meteorological Organization held its fifth session at Geneva from August 25 to September 11, 1954. This meeting differed from the preceding sessions in that it was overshadowed by preparations for the Second Congress, which has now been announced to begin at Geneva on April 14, 1955.

As customary, the Committee divided into two main working groups, dealing with administration and finance and with programme, respectively. It would be inappropriate here to attempt to give a complete summary of the complicated financial and other matters which the first group, under the able chairmanship of Mr. D. A. Davies (President, Regional Association I) sorted out during a very busy three weeks, but it should be mentioned that the Organization has passed through its initial financial period in a very satisfactory manner. Among other things, considerable thought was given to questions of grades, salary scales and structure of the Secretariat for the second financial period which follows Congress. One of the most interesting decisions was that which set up a small working group with a two-fold task: first, to consider plans for the progressive extension of the work of the Technical Division as a "processing centre" for meteorological information, and second, to act as a scientific advisory body on the work of the Technical Division in general. This resolution arose out of the recommendation of a working group on the proposal to set up an international meteorological institute, which was found to be both impracticable and inadvisable at the present time.

The working group on programme, under the chairmanship of Col. Sellick (Rhodesia), had a heavy task, for in addition to the reports of the Regional Associations it had to consider the large and complicated report of the simultaneous session of the Commission for Aeronautical Meteorology (World Meteorological Organization) and the Meteorology Division of the International Civil Aviation Organization. The difficult question of horizontal visibility in meteorological reports occupied much time, and in view of the lack of uniformity which now exists it was decided to ask the various services to carry out, as a matter of urgency, trials on the determination of the so-called "visibility index" in accordance with a procedure laid down by the Executive Committee, and to report results not later than March 1, 1955. At the same time the operational procedure for determining the visibility index was referred to the Commission for Instruments and Methods of Observation for critical examination.

The value of ground radar sets (operated as independent equipment by meteorological services) for weather observations was recognized in another resolution, and it was also decided to instruct the Secretariat to prepare a *Technical Note* giving information about equipment suitable for ground radar weather observations. Members of the Committee felt strongly that unless such equipment was under the complete control of the meteorological officer at an aerodrome its value would be greatly reduced, and in the course of the discussion the interesting point was made that the optimum wave-length for meteorological observations is possibly neither 3 cm. nor 10 cm. but an intermediate length about 5 cm.

For high-level forecasts, a resolution was adopted urging the services to greater efforts in charting the atmosphere above the 200-mb. level, to consider the routine construction of charts showing the height of the tropopause, and to develop techniques for forecasting the vertical extent of cumulonimbus clouds and the extent of cirrus up to the levels required for modern aircraft. After some discussion on ways and means, it was decided to leave it to the Regional Associations to make arrangements for meetings of forecasters from different countries to pool and exchange information on high-level forecasting. Another *Technical Note* planned is one describing progress in research on turbulence and gusts.

The importance of winds over mountains was recognized, and it is gratifying to the Meteorological Office to know that a projected *Technical Note* on this subject will probably be based largely on the excellent report which Mr. Corby made recently to our own Meteorological Research Committee.

The reports of two other Commissions, those for Agricultural Meteorology and for Bibliography and Publications, were also considered. These generally were less controversial, and the Committee expressed its satisfaction with the considerable progress being made in both fields. Arising from the report of the Commission for Bibliography and Publication, the Executive Committee, not unexpectedly, found it difficult to reach a final decision on the International Meteorological Bibliography, and in the end postponed matters by instructing the Secretariat to inquire of members what material they would wish to see included, and how soon after publication a list of such papers could be sent to Geneva. This reflects the general opinion that the value of a bibliography depends very much on its appearing within a relatively short time, say a few months at the most, after the publication of the papers.

Another recommendation which gave rise to much discussion was that dealing with a possible World Climatological Atlas. The difficulty here is two-fold. In the first place, some excellent regional atlases already exist or are in active preparation, and secondly, the preparation of a world atlas *ab initio* by the World Meteorological Organization would be a very long and costly task. It was decided to ask the Commission for Climatology, in consultation with the Regional Associations and the Technical Commissions concerned, to draft specifications for (*a*) a single climatological atlas covering the whole world and based on a strictly uniform plan and (*b*) a series of national, sub-regional and regional atlases which together could be considered as constituting a World Climatological Atlas. The final decision is to be left to the Second Congress.

Among other matters of general interest dealt with by the Committee the following two items may be mentioned. The continuance of the North America Continental Broadcast (WSY) was urged, together with a request that Governments concerned should hasten the change over to radioteletype, a step which is much desired by the United States. *Technical Notes*, which have already gained a high reputation for clarity, reliability and impartiality, are, in future, to have abstracts in all the official languages (English, French, Russian and Spanish) of the Organization. This should go far towards securing a wider circulation of these publications.

Finally, some mention should be made of the resolution on atomic explosions and weather. Not unnaturally, this attracted the attention of the Press of the world, and it is most unfortunate that some of the published accounts were, to say the least, fanciful. No member of the Executive Committee expressed a belief in the reality of a connexion between the explosions and the recent bad summer. The resolution arose from a discussion on a circular letter from the Japanese Meteorological Society which mentioned the possibility of such an effect, and the Executive Committee decided that the World Meteorological Organization, as an international organization, should attempt a proper scientific examination of a belief which apparently is held by many people all over the world. To this end the Secretary-General was instructed to collect what information he could, it being understood that a *Technical Note* would be published if, and only if, the information so obtained justified it. There was not, as some newspapers asserted, any "agreement" to pool knowledge, and anyone acquainted with the constitution and duties of the Executive Committee will realize that it has no powers to resolve, or even discuss, such a momentous question. As meteorologists we may welcome this investigation, not because it is likely to produce an answer which will satisfy the layman, but because it focuses attention on the apparent "abnormalities" of climate which have always existed, and any study which may help to establish their nature and distribution on a world-wide basis is therefore unlikely to be wasted.

The fifth session of the Executive Committee meant three weeks of hard work, with meetings running continuously from 9 a.m. to 6 p.m. and often later. Fortunately, we were favoured with good weather (a somewhat unusual blessing for a gathering of meteorologists) and at the week-ends it was possible to blow away some of the smoke-laden atmosphere of the conference rooms in the clean air of the mountains. For this boon we must express our gratitude to those members of the World Meteorological Organization staff who gave so freely of their scanty leisure to show us some of the beauties of their adopted country.

ESTIMATION OF MEAN WINDS AND STANDARD DEVIATIONS AT HIGH LEVELS

By P. GRAYSTONE, B.A.

Summary.—A method is suggested for estimating upper wind means and standard deviations, when only a restricted summary, possibly with a bias towards lighter winds, is available at high levels. Tests indicate that the method can be used with some confidence even when only a small proportion of ascents reach the required level, and that the corrections necessary are smaller than has generally been supposed.

Introduction.—Upper wind statistics at high levels are frequently based on incomplete data, chiefly owing to a tendency for the balloon to be carried out of radar or visual range by strong winds. There are in fact hardly any complete summaries available above 150 mb., and at some stations, e.g. in the subtropical jet-stream zones, considerable losses occur below 200 mb.

Correlation of wind with height.—Provided that a complete set of observations is available at a lower level, the true vector mean and standard vector deviation at the higher level can be estimated on the assumption that the correlation between winds at the two levels is the same in the case of the missing winds as for the whole set.

Let N be the total number of observations at level 1, of which a are missing at level 2.

Let $\bar{\mathbf{V}}_1$, $\bar{\mathbf{V}}_2$, σ_1, σ_2 and R be the true vector means, standard vector deviations, and the true correlation coefficient between winds at the two levels. Let $\mathbf{u}_1$, $\mathbf{u}_2$, s_1, s_2 and R' be the vector means, standard vector deviations and correlation coefficient based on $N-a$ observations only.

Given a wind $\mathbf{V}_1$ at one level, the most probable wind $\mathbf{V}_2$ at another level is

$$\mathbf{V}_2 - \bar{\mathbf{V}}_2 = R\,\frac{\sigma_2}{\sigma_1}\,(\mathbf{V}_1 - \bar{\mathbf{V}}_1)$$

and the mean square vector error is $\sigma_2^2\,(1 - R^2)$.

These equations, applicable strictly to the whole set of observations, are assumed to be valid for the a missing observations, which are therefore given by

$$\mathbf{V}_2 = \bar{\mathbf{V}}_2 + R\,\frac{\sigma_2}{\sigma_1}\,(\mathbf{V}_1 - \bar{\mathbf{V}}_1) + \mathbf{k}$$

where $\sum_1^a \mathbf{k} = 0$ and $\frac{1}{a}\sum_1^a \mathbf{k}^2 = \sigma_2^2\,(1 - R^2)$.

A further necessary assumption is that there is no correlation between the wind at the lower level, and the departure of the wind from its most probable value at the higher level, i.e.

$$\sum_{1}^{a} \mathbf{k}\,\mathbf{V}_1 = 0.$$

The values of $\overline{\mathbf{V}}_2$, σ_2 and R are as yet unknown.

Derivation of formulae.—

Now
$$\overline{\mathbf{V}}_2 = \frac{1}{N}\sum_{1}^{N} \mathbf{V}_2$$
$$= \frac{1}{N}\sum_{1}^{N-a} \mathbf{V}_2 + \frac{1}{N}\sum_{1}^{a}\left\{ \overline{\mathbf{V}}_2 + R\frac{\sigma_2}{\sigma_1}(\mathbf{V}_1 - \overline{\mathbf{V}}_1) + \mathbf{k} \right\}$$

whence, on substituting $\sum_{1}^{a} \mathbf{k} = 0$,

$$\overline{\mathbf{V}}_2 = \mathbf{u}_2 + R\frac{\sigma_2}{\sigma_1}(\overline{\mathbf{V}}_1 - \mathbf{u}_1).$$

Similarly
$$\sigma_2{}^2 = \frac{1}{N}\sum_{1}^{N} \mathbf{V}_2{}^2 - \overline{\mathbf{V}}_2{}^2$$
$$= \frac{1}{N}\sum_{1}^{N-a} \mathbf{V}_2{}^2 + \frac{1}{N}\sum_{1}^{a}\left\{ \overline{\mathbf{V}}_2 + R\frac{\sigma_2}{\sigma_1}(\mathbf{V}_1 - \overline{\mathbf{V}}_1) + \mathbf{k} \right\}^2 - \overline{\mathbf{V}}_2{}^2.$$

Inserting the values for $\overline{\mathbf{V}}_2$, $\sum_{1}^{a} \mathbf{k}^2$ and $\sum_{1}^{a} \mathbf{k}\,\mathbf{V}_1$, we obtain, after simplification,

$$\sigma_2{}^2 = \frac{s_2{}^2\sigma_1{}^2}{\sigma_1{}^2 - R^2(\sigma_1{}^2 - s_1{}^2)}.$$

Finally,
$$R = \frac{1}{N\sigma_1\sigma_2}\left\{ \sum_{1}^{N} \mathbf{V}_1\mathbf{V}_2 - N\overline{\mathbf{V}}_1\overline{\mathbf{V}}_2 \right\}$$

and
$$R' = \frac{1}{(N-a)\,s_1 s_2}\left\{ \sum_{1}^{N-a} \mathbf{V}_1\mathbf{V}_2 - (N-a)\,\mathbf{u}_1\mathbf{u}_2 \right\}.$$

Eliminating $\sum_{1}^{N-a} \mathbf{V}_1\mathbf{V}_2$ and simplifying,

$$R^2 = \frac{R'^2\sigma_1{}^2}{s_1{}^2 + R'^2(\sigma_1{}^2 - s_1{}^2)}.$$

We therefore have the formulae:—

$$R = \frac{R'\sigma_1}{[s_1{}^2 + R'^2(\sigma_1{}^2 - s_1{}^2)]^{\frac{1}{2}}} \qquad \ldots\ldots (1)$$

$$\sigma_2 = \frac{R'}{R}\frac{s_2}{s_1}\,\sigma_1 \qquad \ldots\ldots (2)$$

$$\overline{\mathbf{V}}_2 = \mathbf{u}_2 + R\frac{\sigma_2}{\sigma_1}(\overline{\mathbf{V}}_1 - \mathbf{u}_1) = \mathbf{u}_2 + R'\frac{s_2}{s_1}(\overline{\mathbf{V}}_1 - \mathbf{u}_1) \qquad \ldots\ldots (3)$$

Discussion of formulae.—The formulae are equally applicable to vector and scalar quantities. Equations (2) and (3) are derivable direct from the assumption that the regression equation for the whole set applies also for the partial set a, as this implies that

$$R' \frac{s_2}{s_1} = R \frac{\sigma_2}{\sigma_1}.$$

Equation (1) indicates that a correlation coefficient obtained from an incomplete set will be too low, if, as is usual, $\sigma_1 > s_1$.

The assumptions made in deriving the formulae cannot of course be justified mathematically. Physically they appear reasonable, and are probably the best that can be made. No differentiation is necessary between ascents abandoned owing to the balloon being carried out of range and other causes.

Practical tests.—The method adopted for testing the formulae was to take sets of wind observations which were more or less complete at two levels, and to omit the upper-level observation when the wind speed at the lower level exceeded a certain value. It was not possible to use as tests occasions of very strong wind or to include levels above 150 mb., since in neither case were there any sufficiently complete summaries. On the other hand, the omission of all observations when the wind at the lower level was strong represents a much more rigorous test than occurs in practice.

In the following initial tests in Table I, corrections were made to the wind speed only, the error in direction being small (b = critical speed, at lower level, above which observations at upper level were omitted).

TABLE I

	Levels Lower	Upper	N	a	b	Wind at higher level	R	$\bar{V}$	σ
	Km.	Km.			kt.			kt.	kt.
Tateno Dec. 1950–52	6	9	86	32	80	Uncorrected	0·66	95	38
						Corrected	0·76	111	44
						True	0·68	109	42
Tateno Dec.–Feb. 1950–52	6	9	242	80	80	Uncorrected	0·60	99	45
						Corrected	0·68	112	49
						True	0·66	110	47
	mb.	mb.							
Malta July–Aug. 1950	300	200	112	30	40	Uncorrected	0·47	32	22
						Corrected	0·57	36	23
						True	0·70	36	24

Though upper winds at Tateno (Japan) sometimes show erratic gradients, the results were promising, and further tests were made as in Table II, corrections to wind direction being made as well as to speed.

The corrections to R are frequently erroneous indicating that the correlation in the case of the missing observations does in fact differ from that derived from the lighter winds. That this difference is unimportant is however shown by the high degree of accuracy in the corrected values of **V** and σ. Correlations in the above examples were made below, above and across the tropopause.

In the above tests the value of b was fixed so as to omit about one third of the upper-level winds. To find how the formulae would work with a very restricted summary, three tests were made with a value of b so reduced as to omit three-quarters of the upper-level winds, with the results in Table III. To give an idea of their relative magnitude, all the terms are given for the third example.

TABLE II

	Levels Lower	Upper	N	a	b	Wind at higher level	R	$\overline{\mathbf{V}}$		σ
	mb.	mb.			kt.			°	kt.	kt.
Liverpool Jan.–Feb. 1951	200	150	183	63	40	Uncorrected	0·78	267	15	19
						Corrected	0·88	278	20	25
						True	0·91	280	21	25
Langenhagen July–Aug. 1951	200	150	116	49	48	Uncorrected	0·88	249	18	19
						Corrected	0·93	251	23	25
						True	0·88	252	22	24
Liverpool Apr. 1951–52	300	150	211	69	55	Uncorrected	0·76	280	13	17
						Corrected	0·86	274	17	21
						True	0·82	274	17	20
Habbaniya Apr. 1951–52	300	150	110	37	60	Uncorrected	0·72	267	45	29
						Corrected	0·78	261	52	32
						True	0·70	262	50	31
Downham Market and Hemsby Apr. 1951–52	300	150	223	74	50	Uncorrected	0·70	272	13	16
						Corrected	0·83	274	18	21
						True	0·72	269	17	19

TABLE III

	Levels Lower	Upper	N	a	b	Wind at higher level	R	$\overline{\mathbf{V}}$		σ
	mb.	mb.			kt.			°	kt.	kt.
Liverpool April 1951–52	300	150	211	158	30	Uncorrected	0·58	287	13	13
						Corrected	0·87	280	19	23
						True	0·82	274	17	20
Habbaniya April 1951–52	300	150	110	81	38	Uncorrected	0·67	275	34	25
						Corrected	0·81	262	53	32
						True	0·70	262	50	31
Downham Market and Hemsby April 1951–52	300	150	223	174	20	Uncorrected	0·53	254	8	13
						Corrected	0·88	276	17	22
						True	0·72	269	17	19

At Downham Market and Hemsby $\overline{\mathbf{V}}_1 = 270°$ 23 kt., $\sigma_1 = 40$ kt.
$\mathbf{u}_1 = 258°$ 5 kt., $s_1 = 14$ kt.

The errors in the corrected values of R are now greater, but quite good results, considering the severity of the tests, are obtained for $\overline{\mathbf{V}}$ and σ.

Discussion of results.—The tests indicate that, in general, the formulae can be used with confidence when up to two thirds of the observations are missing, and an approximation can be made when even four-fifths of the ascents fail to reach the higher level. It should be possible therefore to estimate true means and standard deviations up to 100 mb. at most radar stations, and to make a rough approximation for 60 or even 40 mb. in a few cases.

Though the formulae do not specifically require a normal wind distribution, normality is implicit in the idea of correlation. The formulae may therefore be less accurate when the wind distribution at either level is markedly abnormal. This is most likely to occur in jet-stream regions, and in areas experiencing a double wind régime, but even in these cases monthly and seasonal summaries do not often differ seriously from normal.

A noteworthy feature is that the corrections necessary are smaller than has previously been considered likely.[1] At 100 mb. in temperate latitudes, corrections may well be negligible, as balloon losses are primarily caused by strong winds at much lower levels. Table IV gives examples of corrections applied at 100 mb.

TABLE IV

		Wind data at 100 mb. R	$\overline{\mathbf{V}}$		σ
			°	kt.	kt.
Liverpool, January–February 1951 (118 observations at 100 mb., 183 at 150 mb.)	Uncorrected	0·86	277	15	20
	Corrected	0·88	279	15	22
Downham Market and Hemsby, April 1951–52 (163 observations at 100 mb., 223 at 150 mb.)	Uncorrected	0·89	267	11	14
	Corrected	0·90	270	11	15

The labour required to compute a correlation coefficient is considerable, but if this can be estimated—and a sizable error can be made without materially affecting the result—the corrections can be applied easily in process of computing wind statistics in the usual way. Assuming a correlation coefficient R, the formulae are then:—

$$\overline{\mathbf{V}}_2 = \mathbf{u}_2 + R\frac{\sigma_2}{\sigma_1}(\overline{\mathbf{V}}_1 - \mathbf{u}_1)$$

and

$$\sigma_2 = s_2\sigma_1\,[\sigma_1{}^2 - R^2\,(\sigma_1{}^2 - s_1{}^2)]^{-\frac{1}{2}}$$

where, as before, $\overline{\mathbf{V}}_2$, σ_2, $\overline{\mathbf{V}}_1$ and σ_1 are the true means and standard deviations at upper and lower levels respectively, while $\mathbf{u}_2$, s_2, $\mathbf{u}_1$ and s_1 are corresponding values based on incomplete summaries.

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2. DURST, C. S.; Variation of wind with time and distance. *Geophys. Mem., London,* **12,** No. 93 (in the press).

SOME AIRCRAFT AND SURFACE METEOROLOGICAL OBSERVATIONS MADE AT KHARTOUM IN JULY 1952

By P. GOLDSMITH

Summary.—In July 1952, during tropical tests of an aircraft at Khartoum, opportunities occurred of making measurements of temperature and frost point up to 39,000 ft. using an aircraft flat-plate thermometer and a Dobson-Brewer hygrometer. These humidity data are probably the first accurate measurements made at high levels in the tropics and the soundings are described. In conjunction with this work surface observations of solar radiation with a Michelson actinometer were also made, and have been utilized to obtain estimates of the various radiation components in the tropics.

Aircraft measurements of temperature and humidity at high altitudes.—Three ascents were made, two in the day-time and one at night, and the results have been plotted in Figs. 1–3. The instruments used were the Meteorological Office flat-plate thermometer, with readings corrected for airspeed to obtain air temperature, and a pressurized Dobson-Brewer hygrometer to obtain humidity. For comparison purposes the results of the nearest

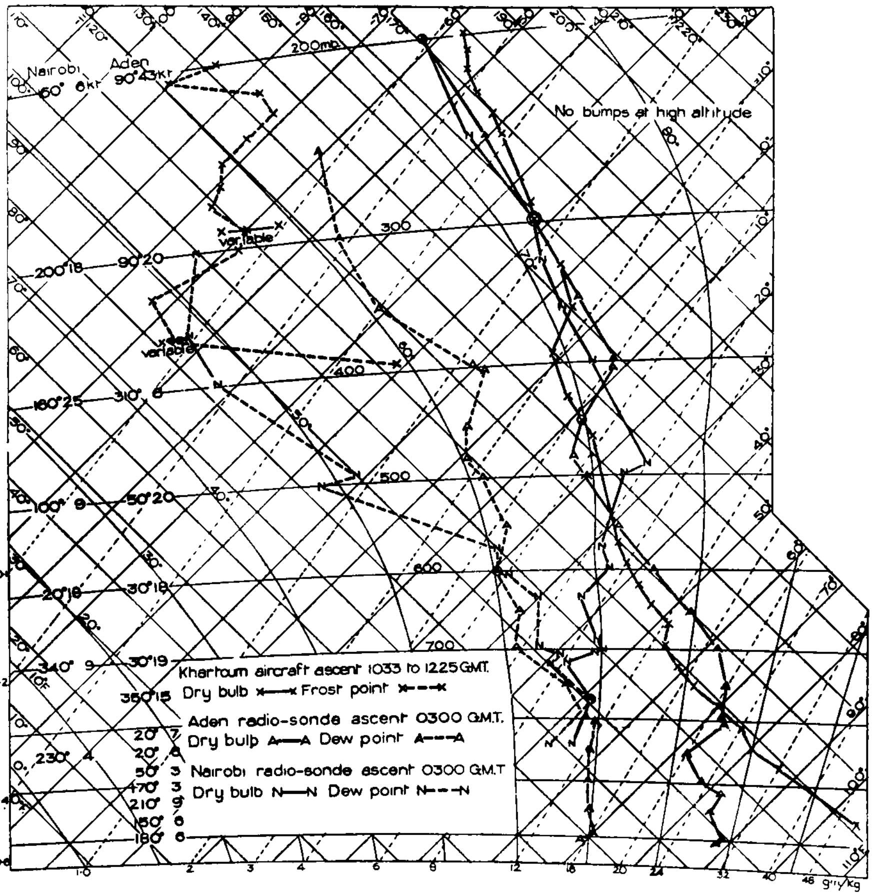

FIG. 1—TEPHIGRAM OF RADIO-SONDE ASCENTS FROM NAIROBI AND ADEN TOGETHER WITH AIRCRAFT ASCENT FROM KHARTOUM, JULY 12, 1952

The winds at corresponding heights above Nairobi and Aden are given on the left, aircraft observations at Khartoum on the right.

radio-sonde ascents have also been plotted (Nairobi is about 1,000 miles south-south-east of Khartoum and Aden about 800 miles east-south-east of Khartoum). The main interest of the temperature readings in each case is the general agreement between the form of ascents at Aden and the aircraft ascents at Khartoum. In each case there is a decrease of the lapse rate around or rather above 20,000 ft. at Khartoum, the similar feature at Aden being rather lower. Above 25,000 ft. the Aden, Nairobi and aircraft ascents are broadly similar. The decrease in lapse rate at Aden coincided in each case with a change from a north-easterly to an easterly wind régime.

The frost-point readings are of the same magnitude as those normally found at about the same height by the Meteorological Research Flight in England. However at Khartoum this height is only in the middle troposphere whereas in England it is usually around tropopause level. The humidity usually showed an appreciable decrease above the more stable layer.

Discussion.—It has been shown by E. E. Austin[1] that easterly winds are persistent at Aden in July up to great heights. The vector resultants quoted

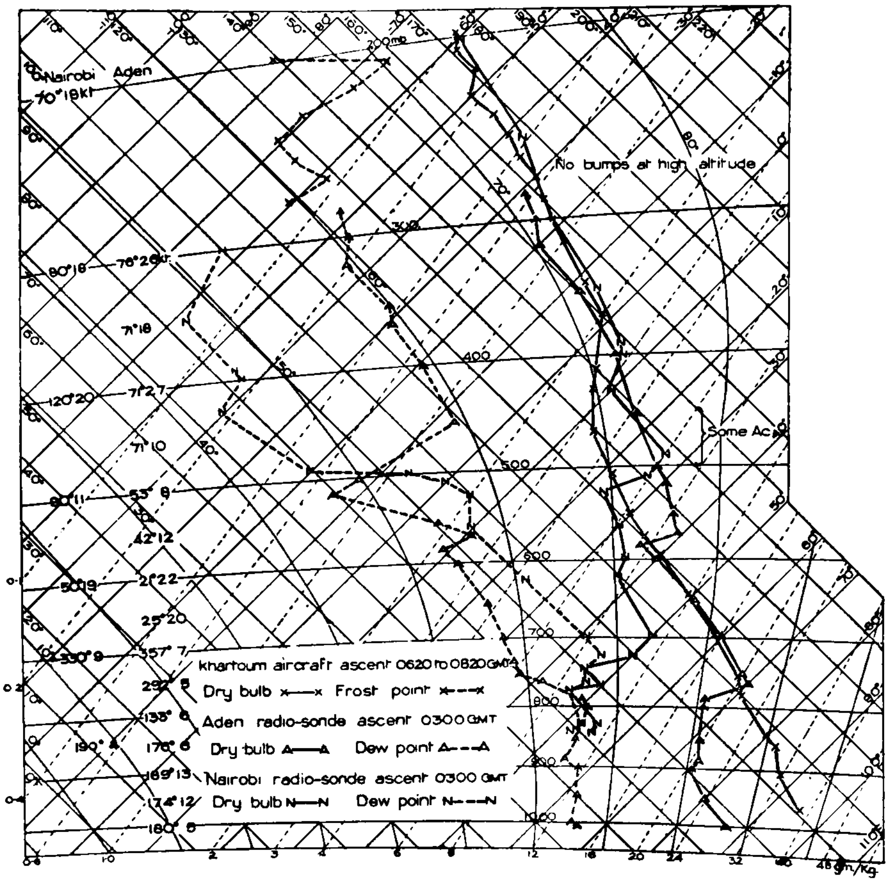

FIG. 2—TEPHIGRAM OF RADIO-SONDE ASCENTS FROM NAIROBI AND ADEN TOGETHER WITH AIRCRAFT ASCENT FROM KHARTOUM, JULY 14, 1952

The winds at corresponding heights above Nairobi and Aden are given on the left, aircraft observations at Khartoum on the right.

in Table I of that paper for July are as follows:—

	Pressure (mb.)						
	850	700	500	300	200	150	100
Vector resultant direction	278°	29°	45°	80°	90°	93°	94°
Speed (kt.)	5	3	13	23	48	71	66

From this it is apparent that the onset of the main easterly stream occurs between 500 and 300 mb., i.e. between 20,000 and 30,000 ft. The Aden soundings discussed above all exhibited this feature and the evidence is that the addendum to E. E. Austin's paper by C. S. Durst, namely that "between 35,000 and 40,000 ft. easterly winds of the same magnitude as at Aden extend over Abyssinia and the Sudan", can probably be extended to include the range 25,000–35,000 ft. in July.

It has been demonstrated that providing the necessary supplies of liquid oxygen can be obtained locally the Dobson-Brewer hygrometer can readily be operated in the tropics. Provided also that attention is given to the effect of the high temperatures (about +130°F.) and humidities in the aircraft on the ground on components such as rubber seals, wiring, etc. there should be

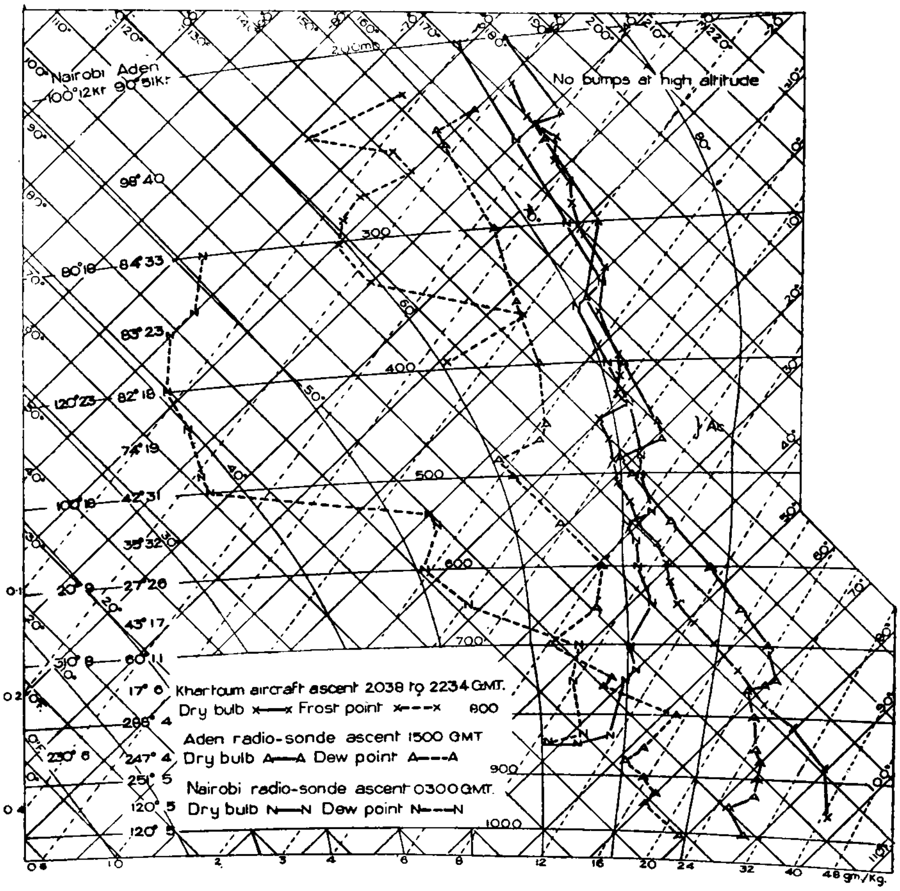

FIG. 3—TEPHIGRAM OF RADIO-SONDE ASCENTS FROM NAIROBI AND ADEN TOGETHER WITH AIRCRAFT ASCENT FROM KHARTOUM, JULY 15, 1952

The winds at corresponding heights above Nairobi and Aden are given on the left, aircraft observations at Khartoum on the right.

no difficulty in extending this work to tropical regions if this should be required. A possible limitation on the use of the instrument is discussed below.

It is known that at frost points of about −120°F. and below, the frost deposit becomes glacial, and so the Dobson-Brewer hygrometer has a lower limit of about −120°F.

It can be seen from Figs. 1–3 that frost points of about −80°F. have been measured at 38,000 ft. in Khartoum with an air temperature of −60°F. The tropopause was at about 57,000 ft. with an air temperature of −110°F. approximately. It seems that, unless the tropopause region in the tropics is always saturated, frost points of −120°F. or lower would be expected there. Although considerable cirrus is found in the tropics, it is not, however, considered likely that saturation will always exist near the tropopause there.

It is interesting incidentally to note that, as temperatures of −130°F. have been reported at moderate altitudes during the polar night[2], this instrument may also fail at high latitudes, and for accurate humidity readings at high altitudes in both tropical and polar regions a new type of instrument will be required.

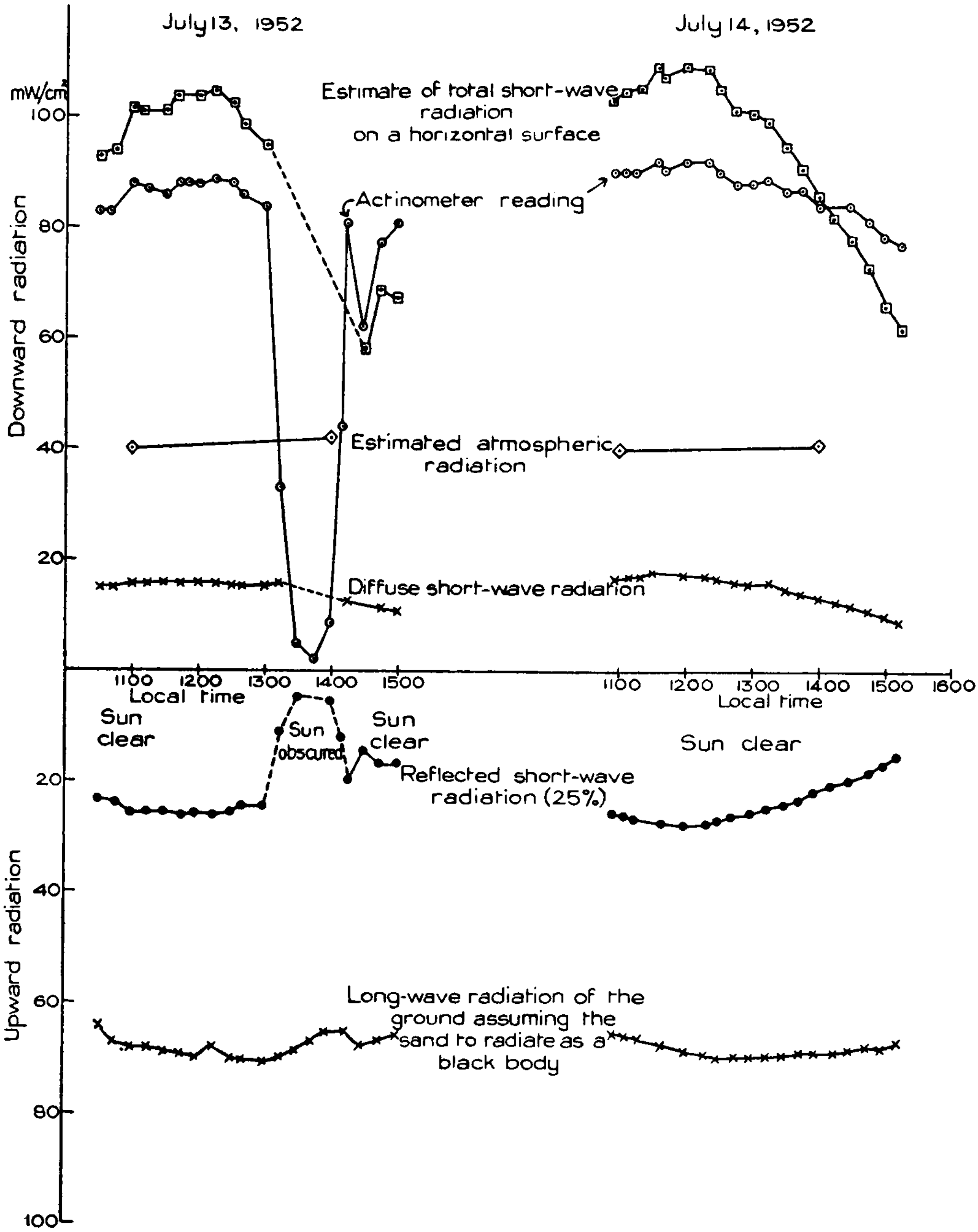

FIG. 4—RECONSTRUCTION OF THE RADIATION FIELD AT KHARTOUM, JULY 13 AND 14, 1952

Surface radiation measurements.—In the estimation of the various radiation components at Khartoum only that from the direct solar beam was measured directly, the others being estimated using other available data. For these extractions and advice on this part of the work I am indebted to Dr. G. D. Robinson and Mr. J. MacDowall of Kew Observatory. The method of obtaining the various components was as follows:—

Direct solar beam.—A Michelson bimetallic actinometer, which had previously been used in Khartoum for other work, was borrowed from Kew Observatory and used for regular measurements of the intensity of the direct solar beam. The sun's zenith angle was also noted at each reading. This instrument was calibrated at Kew before and after use in Khartoum by comparison with a sub-standard Ångström pyrheliometer.

Scattered solar radiation.—This was estimated using an empirical relation between the intensity of the direct solar beam and the intensity of diffuse radiation given by Kimball[3].

Short-wave radiation reflected from the ground.—It was assumed[4] that the sand surface would have a reflectivity of 0·25, i.e. that this component was 0·25 times the sum of the intensities of the direct solar beam received on a horizontal surface and the diffuse radiation.

Atmospheric long-wave radiation.—This component which is dependent mainly on the absorption bands of water vapour and carbon dioxide in the atmosphere is readily estimated by means of a radiation chart when an upper air sounding is available. In view of the general good agreement between the upper air measurements of the three flights and the relevant Aden radio-sonde ascents it was considered that a reasonably accurate value (say ± 15 per cent.) of this component could be obtained by using the Kew radiation chart in conjunction with estimated values of upper air temperature and humidity based on Khartoum surface measurements and Aden radio-sonde measurements on these occasions.

Long-wave radiation from the ground.—Ground temperatures were measured at regular intervals by means of a thermometer with its bulb immersed to a depth of one inch in the sand. This component was then calculated from the sand temperature on the assumption that for the wave-lengths involved the sand radiates as a black body.

Results.—Fig. 4 shows the computed values throughout the day at Khartoum on July 13 and 14, 1952. If we compare the approximate values of these components with representative values at Kew for a cloudless summer day Table I is obtained. This comparison is of course very approximate and for more accurate work direct measurement of the diffuse sky radiation and reflectivity of the soil would be necessary.

TABLE I

	Khartoum mW./cm.^{2}	Kew mW./cm.^{2}
Direct solar beam (local noon)	90	80
Scattered solar radiation	15	15
Reflected short-wave radiation	25	15
Atmospheric long-wave radiation	40	30
Ground long-wave radiation	70	55

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3. KIMBALL, H. H.; Variations in the total and luminous solar radiation with geographical position in the United States. *Mon. Weath. Rev., Washington D.C.*, **47**, 1919, p. 769.
4. Washington, Smithsonian Institute. Smithsonian meteorological tables. *Smithson. misc. Coll., Washington D.C.*, **114**, 6th revised edn., 1951, Table 154.

AERIAL OBSERVATION OF TOTAL SOLAR ECLIPSE JUNE 30, 1954

By G. W. HURST, B.Sc.

I had the good fortune to be given the opportunity to make a flight over the eclipse area on June 30 in a Canberra; the pilot was the Squadron Commander, Sqdn-Ldr K. Ritchley, and the navigator F.O. Powell. Take-off was from Wyton at 1015 G.M.T., and the aircraft reached the Faeroes area at 1145; 25 min. were spent flying to the west and back (still in the belt of totality) so that the original flight plan of setting a course of 110° from the Faeroes at 1210 could be followed. The aircraft was within the area of totality until about 1250.

The flight north was fairly uneventful; the synoptic situation at 1200 G.M.T. was one of a wide warm sector between a warm front off the Norwegian coast and a cold front east of Iceland to the south-west. The climb had been through multilayered thick cloud in sheets at medium level, and in the flight north there were isolated patches of cirrus at about 35,000 ft. There was the curious effect in the Newcastle area of bands of cirrus orientated west to east apparently above aircraft level, which were difficult to see as they were approached, but proved to be distinctly below flight level (probably owing to the rate of climb of the aircraft). From the Border northwards the aircraft was well above the tropopause, and there was for the most part a complete cloud layer below, with a top at about 5,000–10,000 ft. above sea level. It was, however, of real interest to see the orographic clearances over the east coast of Scotland, where the east of Fife, Dundee and the coast northwards to Rattray Head enjoyed a substantially clear sky. At about 58°N. (1115 G.M.T.) slight clear-air turbulence was felt; this was short-lived—about half a minute. There was a fairly marked discontinuity between Leuchars and Stornoway, winds at 1500 G.M.T. varying from 270° 9 kt. to 246° 44 kt. at 200 mb. with a less marked change from 301° 5 kt. to 238° 27 kt. at 170 mb.

The eclipse was first noticed at 1115 as a small bite out of the right of the sun just above the centre line. As the flight progressed and the eclipsed area of the sun increased the darkened sector moved across to a central position on the right of the sun's disc. Loss of light was not particularly obvious until the sun's surface was three-quarters obscured, although the pilot assured me that the glare from the cloud surface below (still 8 oktas of low cloud) was very much less than normal. From this point onwards however the light fell off noticeably, and by the time totality was near, cockpit lights for both the navigator and pilot had to be switched on. A very interesting point was the sudden onset of totality, which was as sharp as the snap of a switch. The spectacle of the eclipse spreading slowly along the cloud sheet ahead was most impressive, with the foreground darkened and the background comparatively brilliantly illuminated.

Totality lasted from 12h. 22m. 30s. to 12h. 26m. 10s., and during this time the sun was surrounded by the corona, which extended equatorially to a distance about equal to the sun's diameter in each direction; there was slight lack of symmetry early and late in totality. The polar extension was about half the sun's diameter in each direction. Venus, at an elevation of about 40° to the south-east, was quite clearly visible during the darkness (which corresponded almost to that of moonlight, though the sky retained a deep blue rather than a black appearance). Other observers also saw a star to the south-south-west (probably Aldebaran) but the view of a passenger from a Canberra is rather restricted, and I was also engaged in taking photographs with two cameras. Cessation of totality was as sharp as the onset, and light rapidly increased.

There is no doubt, incidentally, that our track was directly along the central line of the belt of totality (which reflected very well on the navigator whose flight from Cape Wrath, an hour earlier, to the north-west was by dead-reckoning) as the sun immediately before and after obscuration showed a vertical arc, and as the time of totality was 3 min. 40 sec., the maximum possible. For a ground observer, the maximum period of totality was 2 min. 35 sec. which, taking into account the speed of movement of the eclipse (approximately 1,800 m.p.h.) and the ground speed of the aircraft (about 460 kt.), gives for the air observer a period of

$$\frac{155 \times 1800}{1800-460(38/33)} = 220 \text{ sec.} = 3 \text{ min. } 40 \text{ sec.}$$

The flight was continued down the eclipse line towards Norway, and in the distance could be seen the dark eclipsed horizon with, to the south-east and east, horns of illuminated cloud. These horns gradually closed in, and eventually, the whole horizon was again illuminated. It was difficult to fix the time when this occurred, as the horizon had not the "hard" appearance immediately ahead of the aircraft which it had to the port and starboard, but there was no doubt that by 1242, at the latest, illumination was restored to all the world visible from 45,000 ft. The speed of sweep of the eclipse based on the 15 min. 50 sec. interval between first clearance of the moon overhead and at the horizon was estimated at 1,480 m.p.h. This estimate is based on the assumptions that the ground speed was about 460 kt., and the height of the horizon ahead 3,000 ft. above sea level. The latter is reasonable as Oslo, which would be just north of the horizon ahead, was reporting 3 oktas of stratocumulus at 1,500 ft. at 1200 G.M.T. and high ground just to the west extended to approximately 3,000 ft. The height of the aircraft above the horizon was therefore 45,500 − 3,000 ft., i.e. 8 miles, and the distance of the horizon about 250 miles. The speed of movement of the eclipse is therefore

$$250 \times \frac{60}{15{\cdot}83} + 460 \times \frac{38}{33} = 1{,}480 \text{ m.p.h.}$$

This compares with the actual speed of 1,800 m.p.h. of the speed of passage of the eclipse, so it is clear that totality had ceased on the eastern horizon a few minutes earlier than the last time we recorded.

On the return flight the cloud sheet extended over the whole of the eclipse area to the west coast of Norway in the vicinity of Bergen, but, travelling back, over east Scotland there were again substantial breaks over the coastlines of the Moray Firth, though high ground was in cloud. To the south, the Tay Bridge could be seen, and so could Perth, but the Forth Bridge was covered, and no ground could be seen over England until descent at 1415 G.M.T.

Attempts were made at photography from the start of the eclipse until just after totality had ended. The instruments used were a normal hand-held service camera and a 35-mm. ciné camera. The former was used before the eclipse and during early totality, and the latter during late totality (taken as a

MEMORIAL TABLETS AT KEW OBSERVATORY

(see p. 321)

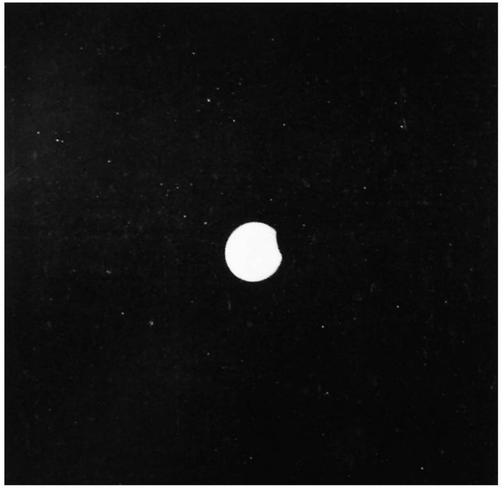


FIG. 1–1115 G.M.T.

FIG. 2–1200 G.M.T.

FIG. 3–1220 G.M.T.

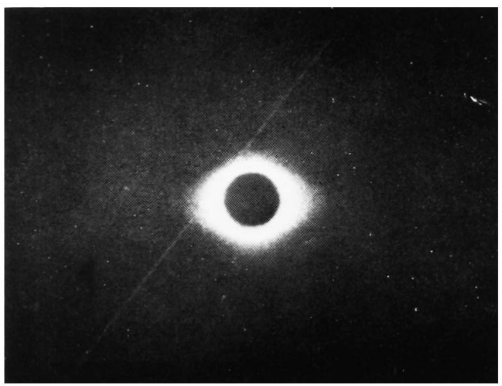


FIG. 4–1225 G.M.T.
(totality)

FIG. 5–1226 G.M.T.

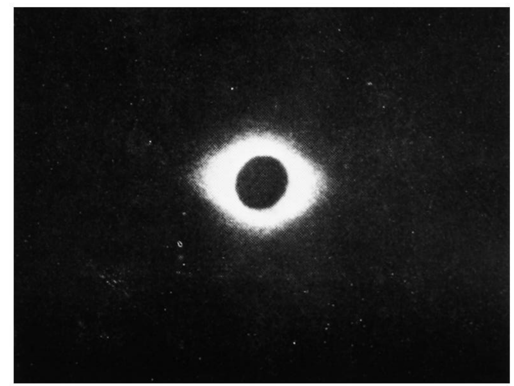


FIG. 6–1226 G.M.T.

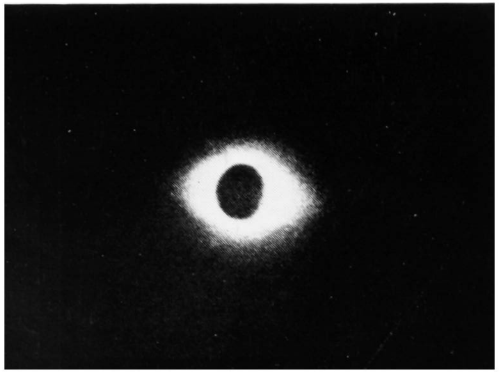


FIG. 7–1226 G.M.T.

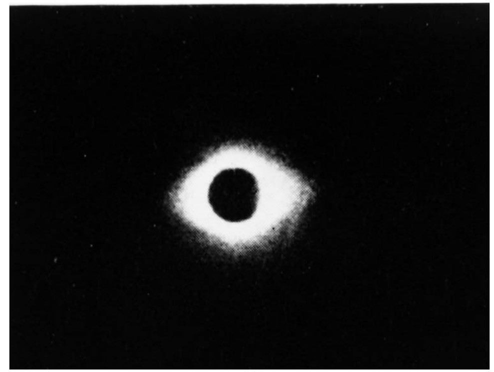


FIG. 8–1226 G.M.T.

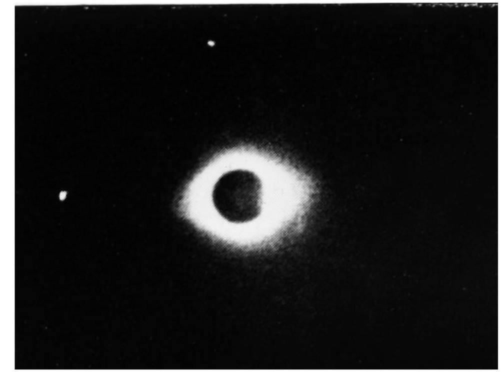


FIG. 9–1226 G.M.T.

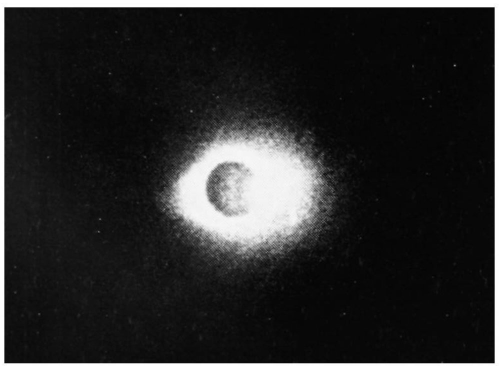


FIG. 10–1226 G.M.T.

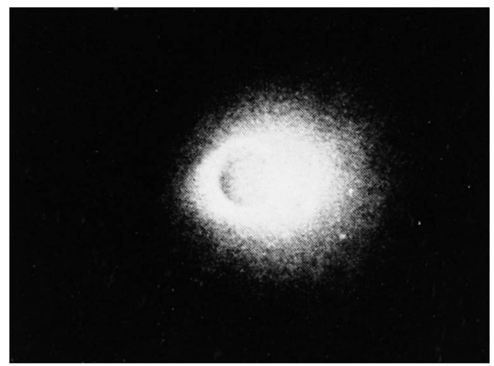


FIG. 11–1226 G.M.T.

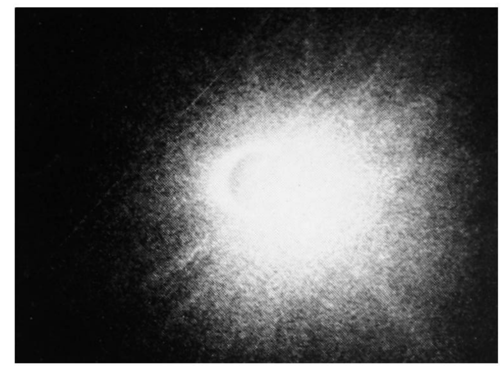


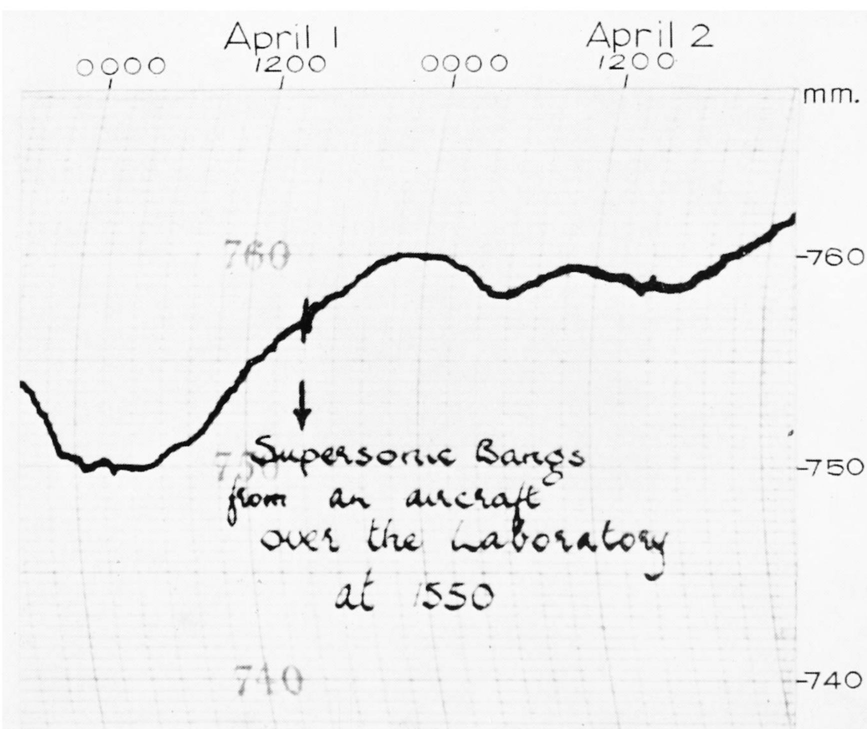
FIG. 12–1226 G.M.T.

PHOTOGRAPHS OF THE ECLIPSE TAKEN FROM A CANBERRA AIRCRAFT IN THE BELT OF TOTALITY AT ABOUT 45,000 FT.

The first three photographs were taken with a normal hand-held service camera using an infra-red plate, the other nine being taken with a ciné camera using a yellow filter. The last eight photographs near the end of totality were taken at 1-sec. intervals. The aircraft was moving in the direction of motion of the shadows and totality lasted from 12h. 22m. 30s. to 12h. 26m. 10s. (see p. 335).

Reproduced by courtesy of the late W. J. Day

ALTOCUMULUS



BAROGRAM FROM THE VETERINARY LABORATORY AT WEYBRIDGE, SURREY, SHOWING THE RECORD OF THE OCCURRENCE OF A SUPERSONIC BANG (see p. 348)

film) and just after. The difficulty of handling these, especially the bulky service camera, in the restricted cockpit of the Canberra was great, and photographs were not in many cases as satisfactory as had been hoped. In particular, no successful shots were obtained of totality with the service camera, though quite good ones emerged using the ciné camera. In general, photographs showing any direct light from the sun were taken through an infra-red filter (which appears almost opaque unless viewed directly against a strong light source), and photographs during totality were taken with a yellow filter and as great an aperture as possible. A selection of the photographs is reproduced in the centre of this Magazine.

It will be seen that the end of totality was indeed very sharp, and Fig. 11 can be regarded as the point of return of the sun's light. The suddenness of the change between Figs. 8 and 12 will be noted.

RADIO-SONDE ASCENTS DURING THE SOLAR ECLIPSE JUNE 30, 1954

By A. P. TAYLOR, B.Sc.

The heating of radio-sonde temperature elements by insolation causes errors in the temperatures reported. Comparisons between day and night soundings fail to determine the magnitude of these errors since diurnal changes of air temperature may account for the whole or part of the observed differences. The eclipse of the sun on June 30, 1954, provided an opportunity of measuring the apparent changes of temperature during a period when the changes of insolation were so rapid that there were unlikely to be any associated changes of true air temperature.

The programme of ascents arranged for all radio-sonde stations in the United Kingdom was:—

(i) one balloon to be released 1 hr. before commencement of the eclipse

(ii) a second balloon to be released 50 min. before the time of maximum phase of the eclipse

(iii) a third balloon (the routine 1500 G.M.T. sounding) to be released approximately 15 min. after the end of the eclipse.

Where possible, stations were asked to duplicate the second ascent by another sounding launched 5 min. later. The soundings were to be followed on both the ascents and descents, and the programme imposed a very rigid time-table on the stations concerned. In spite of adverse weather conditions at the northern stations, and the unfortunate behaviour of some of the special large balloons used, this programme was successfully carried through.

The data obtained from these soundings must be subject to detailed analysis before any final conclusions can be reached, but a preliminary survey shows that the variations of measured temperatures were of the same order as the values calculated by Scrase[1]. In this preliminary survey the thickness from 300 to 100 mb. has been used as a convenient equivalent of mean temperature. The results are given in Table I.

The differences show considerable scatter, the values for Lerwick and Camborne being particularly suspect. The thicknesses were plotted on a chart, together with the shear winds for the same layer, and it seems probable that the value of 23,915 ft. at Camborne is some 200 ft. too great and, though with less certainty, the value of 23,690 ft. at Lerwick is too great by some

TABLE I

	Apparent average thickness 300–100 mb. Before and after the eclipse (1)	At about the time of maximum phase of the eclipse (2)	Difference (1)−(2)
	ft.	ft.	ft.
Lerwick	23,825	23,690	135
Stornoway	23,749	23,530	219
Leuchars	23,364	23,146	218
Aldergrove	23,412	23,170	214
Liverpool	23,567	23,346	221
Hemsby	23,712	23,585	127
Crawley	23,786	23,651	135
Camborne	23,915	23,417	498
		Mean	221

100 ft. If these results are omitted the mean difference becomes 189 ft. Scrase's figures for radiation errors are equivalent to a difference in thickness of the 300–100 mb. layer of 226 ft. The ratio between the computed difference of 226 ft. (for 100 per cent. change in radiation) and the observed value of 189 ft. is 0·83. At the time of maximum phase the eclipse varied from 75 per cent. of totality in the south to almost complete totality at Lerwick. It is reasonable to assume an average of 80–85 per cent. of totality for the six stations used in the mean, and that the insolation was reduced in proportion to the percentage of totality. The figures are in surprisingly good agreement considering the approximations made in this preliminary analysis.

It is interesting to note that in the course of these soundings one radio-sonde carried by a 2,000-gm. balloon released from Camborne reached a height of 100,950 ft. (12 mb.) which is a record height for a normal temperature ascent made by the Meteorological Office. Greater heights have been achieved by balloons carrying only radar targets, modified radio-sondes, or special cosmic-ray equipment, but it is unusual for a radio-sonde to continue to give acceptable readings of both pressure and temperature to such a level.

REFERENCE

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INFLUENCE OF A QUASI-STATIONARY LONG-WAVE PATTERN ON SMALL-SCALE THERMAL FEATURES

By M. K. MILES, M.Sc.

Abstract.—The behaviour of small-scale (i.e. half wave-length about 20° longitude) cold troughs in the 1000–500-mb. thickness pattern was examined during a period of almost stationary long-wave pattern, and it is suggested that there was a dynamical control exerted by the latter with the following three main features:

(i) The tracks of the cold troughs followed the direction of the mean thickness lines for the period.

(ii) They moved very quickly (30° longitude and more a day) while travelling up to the crest of the large warm ridge.

(iii) Dynamical warming occurred in the southern parts of the troughs during this part of their transit.

The half wave-length up to the warm ridge was significantly greater than the Rossby stationary wave-length, implying horizontal convergence at medium and higher levels to the west of the large ridge. The vertical motion deduced from (iii) is suggested as an indication that this was occurring, and was the principal factor influencing the behaviour of the smaller features in this area.

Data.—During the period February 25 to March 9, 1953 there was a quasi-stationary long-wave thermal pattern over the North Atlantic. The mean thickness lines (1000–500 mb.) during March 3–9 show a flat warm ridge with its axis between 0° and 10°W.; the mean up-stream cold trough was at about 60°W. (see Fig. 1).

Individual small-scale cold troughs moving east from the region of the quasi-stationary cold trough showed some characteristic features which seemed to merit closer study. To enable them to be identified during their progress the movement of the 17,400-ft. thickness line on the 1000–500-mb. chart was selected for examination. Air with a temperature distribution corresponding to this thickness is not very far from equilibrium with the sea surface at this time of the year in the latitudes concerned, and this reduces non-adiabatic effects to a minimum.

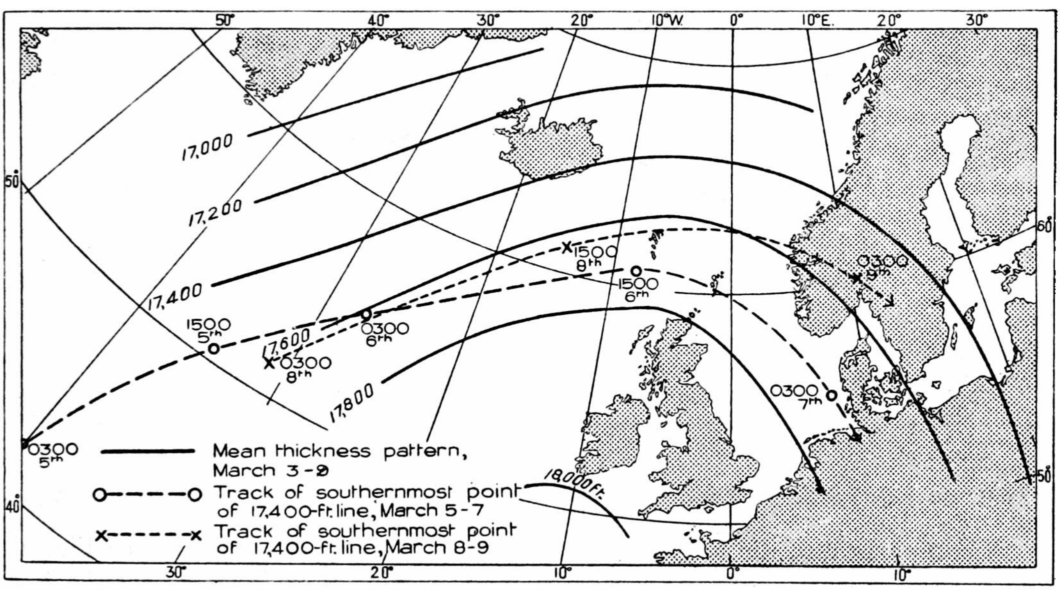

FIG. 1—MEAN 1000–500-MB. THICKNESS PATTERN, MARCH 3–9, 1953

The first example occurred while the quasi-stationary régime was being established. A cold trough with its base, i.e. the most southerly position of the 17,400-ft. line, at 34°W. at 0300 G.M.T. on February 26 had moved to 2°W. 24 hr. later—an unusually rapid motion. Further its base moved from latitude 47° to 60°N. in this period. The large change in the position of the 17,400-ft. line suggests some other warming agency besides the strong southerly winds in mid Atlantic.

The next one on March 1–2 also moved rapidly, going from longitude 30°W. to 0° in 24 hr. The third one on March 5–6 made an almost similar passage (35°W. to 5°W.) in the 24 hr. from 1500 on March 5, while the last one studied travelled from 33°W. to 10°E. between 0300 on March 8 and 0300 on March 9.

Discusssion.—All the tracks could be seen to follow fairly closely the mean total thickness pattern (only two sets are shown on Fig. 1 to avoid confusion), and all moved very fast (over 30° longitude a day) while coming up to the axis of the quasi-stationary warm ridge.

A study of the relevant surface and thickness charts suggests that these features cannot result entirely from advection. In particular the movement of the base of the troughs round the mean pattern appears surprising in view of the westerly surface winds observed behind the cold fronts. These winds, though fairly limited in extent, imply some cold advection towards the mean ridge.

To examine this effect more closely the cases of March 5–6 and 8–9 were selected for more detailed examination. Trajectories based on the geostrophic surface wind were constructed for points on the 17,400-ft. line of the cold trough. This gives a first approximation to the motion of a thickness line, and should enable an estimate to be made of, at least, the sign of any dynamical effect.

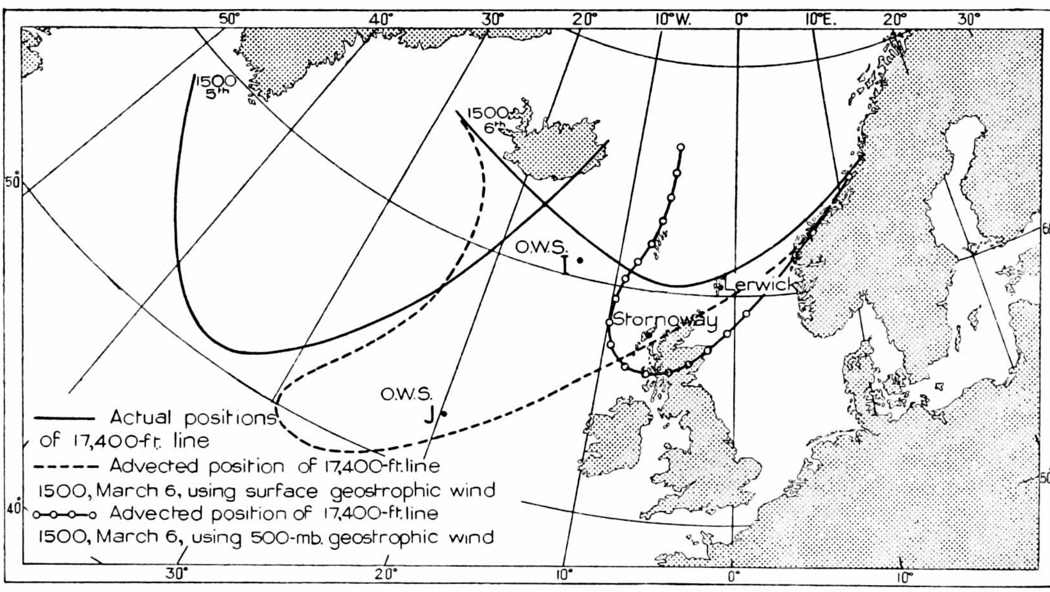

FIG. 2—POSITIONS OF THE 17,400-FT. THICKNESS LINE ON MARCH 5 AND 6, 1953

A comparison of the actual and advected positions on March 6 (see Fig. 2) reveals that a very large area was warmer than might have been expected. The tephigrams for stations in this area were then examined, and at Stornoway and Lerwick there was clear evidence of deep subsidence. At ocean weather stations I and J there was a shallow dry layer with warmer and moister air above. This suggests that the 2,000-ft. trajectories were not giving the true advection at higher levels and approximate trajectories on the 500-mb. surface were drawn. As the map shows, these indicate that warmer air could have been brought to stations I and J at 500 mb. but not to Lerwick and Stornoway. This means that over all the area there was some dynamical warming, and, in a smaller area at the base of the trough, dynamical warming occurred through a deep layer. On March 8–9 the details are quite different but the map (Fig. 3) shows a significant area including station I and Lerwick where warming may have taken place. The ascent at I shows an inversion from 925 to 850 mb. and some evidence of subsidence, but again there is moister air above 600 mb. The

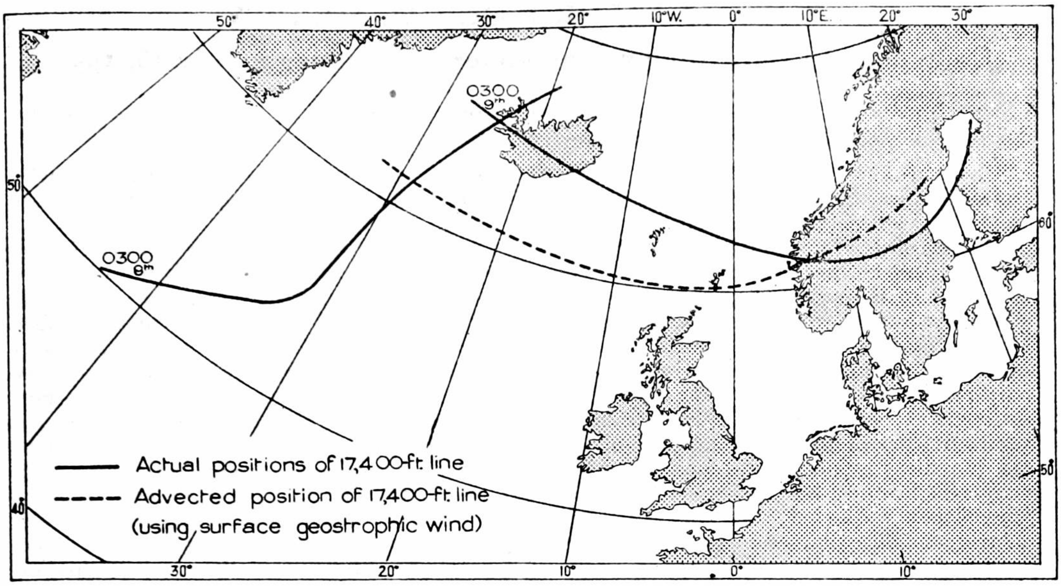

FIG. 3—POSITIONS OF THE 17,400-FT. THICKNESS LINE ON MARCH 8 AND 9, 1953

ascent at Stornoway (outside the area enclosed) shows very dry air above 900 mb. Thus again it seems likely that dynamical warming was occurring. Such dynamical warming of the cold trough, especially of the south-west part, can itself result (see Fig. 4) in an eastward displacement of the axis and a northward movement of a given thickness line.

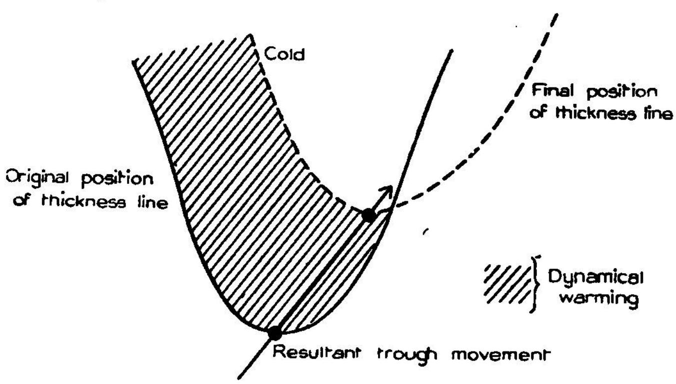

FIG. 4—AREA OF DYNAMICAL WARMING

Conclusion.—There is little doubt that some such process as this played a part in producing the very rapid motion of the cold troughs and their movement along the mean thickness lines. It is interesting to speculate as to whether descending motion to the west of the warm ridge could have been an essential factor in the maintenance of the quasi-stationary pattern. The separation of the ridge from the principal up-wind cold trough was of the order of 60° longitude, and this is greater than required in constant-vorticity flow. There may then have been development of cyclonic vorticity by horizontal convergence to the west of the ridge axis accompanied by descending motion below 500 mb. Thus it is not unreasonable to infer from the observed behaviour of the small-scale thermal troughs that they were influenced by the structure of the quasi-stationary ridge while moving through it.

ROYAL METEOROLOGICAL SOCIETY

Colloquium on the upper atmosphere, Edinburgh, July 16, 1954

A Royal Meteorological Society discussion presided over by Dr. Sutton, President of the Society, took place in Edinburgh on July 16, 1954.

The discussion was opened by Sir Edward Appleton, Principal of Edinburgh University, who began by enumerating some of the many complexities in the study of conditions in the upper atmosphere where the sun daily performs experiments under conditions which cannot be reproduced in the laboratory. Dissociation and ionization of the air are performed at very low pressures and in the presence of the earth's geomagnetic field which profoundly affects the movement of ionized particles; further complications are caused by the solar and lunar air tides, the effects of which are much more marked in the high atmosphere than near the surface of the earth. Sir Edward described briefly some of the research work which he and assistants had carried out in Edinburgh during the past few years. The E and F1 layers behave reasonably well in accordance with theory, though even in these layers there are small but important discrepancies, whereas the F2 layer shows in various ways large departures from theory. An important step in the understanding of these anomalies had been taken when it was found that the distribution of the ionization accorded much better with geomagnetic than with geographic latitude, and subsequent work, notably by Martyn, has shown that other anomalous features such as diurnal variation and ionospheric storminess, which is manifested mainly in the F2 layer, can be explained by geomagnetic distortion, though no complete theory is yet available. Sir Edward ended by discussing means of obtaining accurate values of the recombination coefficient, and explained how the recent solar eclipse had afforded an opportunity of obtaining such values.

The opening speaker had mentioned that rapid movement is a marked feature of conditions in the upper atmosphere, and most of the subsequent speakers concentrated on this aspect of upper air conditions. The emphasis was certainly on the "upper" regions of the atmosphere, for the lowest level considered was 17 Km. (100 mb.)! Mr. D. H. Johnson of the Meteorological Office gave an account of his investigation of solar tides at this level. Systematic effects were revealed by the regular British upper air observations and possible spurious ways in which these effects might have arisen were carefully considered and rejected. The outcome was that there was satisfactory agreement with the tidal theory appropriate to this level; diurnal and semi-diurnal components of about equal amplitude were found in approximate phase with the surface components and little different in magnitude (0·5–1 kt).

Mr. J. Paton, Lecturer in Meteorology at Edinburgh University, spoke of the noctilucent clouds occurring at the second temperature minimum, at about 80 Km. These clouds are probably of much more frequent and wide occurrence than the comparative paucity of reports would lead one to believe. Though the question is still in doubt, the clouds are probably composed of meteoric dust. Twenty-two occurrences have been observed in Scotland since 1939, and wind speeds of the order of 50 m./sec., always from ENE. have been measured. On one occasion, which was illustrated by slides, there was evidence of a rapid growth of turbulence within the cloud. Mr. Paton also gave an account, in the absence of Dr. A. H. Jarrett of St. Andrews University, of the use of multilayer coatings in auroral work. An auroral spectrograph incorporating these coatings enables an estimate to be made of temperature at the levels at which aurora occurs. Such an instrument is to be obtained on loan from America and installed at St. Andrews.

Dr. I. C. Browne of Jodrell Bank described the results of measurements which have been made of winds in the region 80–100 Km. by observing the radar echoes from the ionized trails of air left by meteors. A large semi-diurnal component, of amplitude up to 30 m./sec. and with phase changing with the season, is superimposed on a smaller general wind. The winds increase markedly with height without changing direction. In reply to Dr. Sutton, Dr. Browne said that the large shear was probably maintained by the temperature distribution at these levels; he answered Dr. Wormell's doubts as to whether the measurements reflected real winds, as opposed to movements of ionized particles, by saying that the ions and electrons were produced within the air molecules and could not drift apart.

The old problem as to whether it is possible to deduce the winds in the lower ionosphere directly from geomagnetic records was discussed by Mr. D. H. McIntosh of Eskdalemuir Observatory. The possibility is based on the atmospheric "dynamo" theory which accounts for the solar and lunar daily geomagnetic variations. This theory and the considerable direct evidence which has accumulated in its support were briefly described. In recent years Wulf and Vestine in America have made strenuous efforts to apply the theory to deduce the general ionospheric winds (as opposed to the periodically varying components) from the magnetic records, but with limited success only. There was hope, however, that when direct measurements are made of the mass movement of the air at the height concerned (about 100 Km.) further progress will be possible.

Dr. H. P. Palmer of Jodrell Bank spoke of the inferences that have been drawn from variations in the intensity of the power of radio emissions received from Cassiopeia and Cygnus. Irregularities in the F region of the ionosphere (200–250 Km.) are considered to be the cause of these variations, and from measurements of small time differences in occurrence of the variations on spaced receivers, drift motions of the irregularities are inferred. These drifts are very large (up to some hundreds of metres per second) and sharp reversals are found to occur during the night, when the fluctuations are found mainly to occur. Dr. Palmer mentioned, but did not enlarge upon, the difficult question as to whether measurements of the type described can be interpreted as true air movements as opposed to movements of ionization clouds only.

The fact that the field of study covered during this meeting was relatively unfamiliar to most of the meteorologists present no doubt accounted for the small amount of general discussion that took place. The mass of the air involved at heights above 50 Km. is so small and the direct relationships with solar conditions become, in contrast to conditions in the troposphere, so well marked that it is almost inconceivable that even routine sounding of conditions in these regions would be of direct help with the central problem of meteorology, that of weather forecasting. As was pointed out, however, in the Editorial to the *Quarterly Journal of the Royal Meteorological Society* for January 1953, the indirect benefits of a better knowledge of conditions in the high regions of the atmosphere may well be considerable. It was clear from this meeting that such knowledge is being acquired rapidly and in a variety of ways.

METEOROLOGICAL MEETINGS OF THE FIFTH CONGRESS OF THE ORGANISATION SCIENTIFIQUE ET TECHNIQUE INTERNATIONALE DU VOL À VOILE

The fifth Congress of the Organisation Scientifique et Technique Internationale du Vol à Voile was held in Buxton from July 20 to August 5, 1954, in conjunction with the World Gliding Championships. Delegates attended from many countries to discuss the technical aspects of glider construction and flying as well as the meteorological factors involved. A short account of the meteorological meetings is given below.

Three days were devoted to meteorology on each of which there were morning and afternoon meetings and meteorological films were also shown. In all about 20 papers were read, the majority of which dealt with some aspect of convection or wave motion although many other related subjects were discussed. Most of the papers were in English, but there were several in German, and contributions in French and Italian were also received. The meetings were conducted in an informal atmosphere, and each paper was followed by a discussion and many questions, whilst *ad hoc* translations and previously prepared abstracts removed many of the language difficulties.

The papers on convection included one by R. S. Scorer* describing it as motion of rising bubbles which, although admitted to be only a hypothesis, appears to fit most of the available observations. A recent paper by C. H. B. Priestley, discussing the behaviour of air rising and exchanging heat and momentum with its environment, was presented in which it was shown that depending on the size of the parcel and the lapse rate it will either have absolute buoyancy, asymptotically approach a certain level, or have oscillatory vertical motion about that level. Although this was welcomed as a mathematical advance in the subject it deals at present only with the dry thermal case, and its claim to experimental verification by observation of the motion of cumulus tops received some comment. Synoptic conditions favourable for long-distance thermal flights over France and the associated forecasting aspects were described by N. Gerbier, and another descriptive paper by R. Maletzke of Germany dealt with convection over the ocean and its differences compared with convection over land. Great interest was aroused by a comprehensive review by J. Küttner of cloud streets. These are apparently a very common manifestation of convection in many countries particularly northern Scandinavia, and a description of their general characteristics was given. Radar pictures of typhoon centres and occasionally fronts also show similar orientations of clouds in lines along the wind direction. Cloud streets almost invariably occur in particular synoptic conditions (usually after a cold front) and with given wind profiles, increasing, decreasing and then increasing again with height. They can be simulated in laboratory experiments, and it appears possible to predict theoretically some of their characteristics, e.g. ratio of cloud spacing to cloud depth. Other papers in this section included one by J. S. Malkus and R. S. Scorer on the erosion of cumulus towers and an account of recent laboratory work on Bénard cells by H. Koschmieder and H. v. Tippelskirch. The circulation of Bénard cells is opposite in direction in liquids and gases, and it appears from the latter paper that this can be identified with the characteristics of the viscosity-temperature relation of the substance (liquid sulphur in the experiments described).

Soaring in nature was the subject of two papers: C. G. Johnson discussed measurements of the density of aphides at different heights with reference to seasonal and diurnal variations of

*SCORER, R. S.; Bubble convection. *Met. Mag., London*, **83**, 1954, p. 202.

the lapse rate, and a paper by R. C. Rainey dealt with locusts and convection currents in east Africa. The shape of the locust swarm may be cumuliform or stratiform according to the meteorological conditions, and the latter is considerably easier to attack by spraying. In both these papers it was stated that one of the most difficult tasks of the entomologist is to separate the biological and meteorological factors in the behaviour pattern of these pests. This field of work appears to be one in which the meteorologist can give considerable help in the future.

The papers on waves amply demonstrated how much our understanding of this subject has progressed in recent years. R. Long showed a film of his experiments with a model barrier towed through a tank containing liquids of density varying with height and showed the different wave profiles produced with different values of the Froude number. He examined theoretically the flow in these conditions for the case of a finite obstacle obtaining good agreement with the model results, and also discussed the applicability of this work to atmospheric conditions. The question of the relative importance of gravity and the wind profile in producing rotor phenomena in the lee of mountains was then considered in a paper by P. Queney, and examples were given showing the great importance of the latter. R. S. Scorer outlined further developments in the use of his l^2 parameter for assessing the probability of waves with particular reference to the effect of inversions, and G. A. Corby discussed its routine application in forecasting work. The approximate variation of l^2 with height can be obtained very quickly by means of a celluloid scale and a plotted temperature ascent on a tephigram. The method assumes that the curvature of the wind profile with height is small, a condition which may not always be satisfied, but Mr. Corby was able to demonstrate with several flight examples that good results are being obtained with this method. Finally the conditions for waves in accelerated flow were examined in a paper by J. Zierep. It was shown that in this case the waves move slowly in the direction of the flow, the phase velocity being about one half of the non-stationary velocity increase.

Among the associated subjects discussed were thunderstorm electricity, which included a general review of the subject by B. J. Mason and some critical remarks on present theories by J. Küttner. The latter also gave a survey of recent jet-stream research in the United States where penetrations of jet streams are now being made frequently with aircraft equipped with continuous wind-recording devices and attempts are also being made to measure vertical air motion from its effect on the aircraft's performance.

Finally there were a number of papers principally concerned with instruments. P. Temple described sensitive thermopile instruments which, mounted on the wing tips of a glider, can measure which is the warmer and possibly indicate to the pilot the direction he should turn to fly into a thermal. P. MacCready discussed the application of gliders equipped with hot-wire anemometers and accelerometers to the investigation of gust loads produced by turbulence. A paper by H. Koschmieder and H. Meyer described new photo-theodolites for plotting cloud contours, e.g. the shapes and sizes of cumulus clouds, and gave examples of results obtained.

The films shown included some beautiful time-lapse films of cloud development from the Munitalp Foundation's series and a film of the Sierra Wave Project presented by J. Küttner. The comprehensive observational work and the brilliant flying of the glider pilots who have attained heights of 44,000 ft. unpressurized aroused much admiration and the results of this work are awaited with great interest.

The amount of new data and results presented at this conference were very considerable, and it is hoped that all the papers presented will be published in the near future.

R. J. MURGATROYD

NOTES AND NEWS

Remarkable temperature variations and fog formation over snow at Stornoway, February 8, 1954

On the afternoon of February 8, 1954, Stornoway was on the western side of a weak ridge of high pressure in rather cold polar air. The ground was completely covered with snow to a depth of 5–6 in., the visibility was excellent, the temperature 3°F. below freezing, the wind almost calm and the sun was shining from almost clear skies. Slight snow showers had fallen fairly frequently from the morning of the 7th and intermittent, at times continuous, moderate snow occurred between 0755 and 1144 on the 8th until the depth at 1200 was 5 in. The sun shone almost continuously from 1125 to 1545. The snow was "steaming" from about 1200 onwards; visible condensation was taking place to a height of about 2 ft. above the surface of the snow.

At 1457 G.M.T., a British European Airways Pionair began to taxi, and, when on full power, to turn, throwing small particles of snow in a swirling cloud above the tower and screen enclosure to a height of 40–50 ft. Subsequent events were startling. First the snow particles settled and shallow fog formed in the region where the snow had subsided. After this the fog, which was very clean, rapidly spread in all directions until within a quarter of an hour the whole of the airfield basin was covered with fog to a depth of 13–35 ft. A bank of fog was also seen to move down the main road at Garrabost, 2 miles away. Previous arrivals and departures of the same aircraft had been without incident.

The screen temperature in the fog rapidly dropped until it had reached 13·9°F., the lowest registered at Stornoway since 1945. Shortly afterwards a light breeze cleared the fog and the temperature rose again to near freezing. A thermometer put into the snow to a depth of 1½–2 in. registered 18°F., 2°F. higher than the screen temperature. Throughout the fog, snow continued to melt and drip from roofs at 10 ft. or above. Fuller details are given in Table I.

TABLE I—SURFACE DATA, STORNOWAY, FEBRUARY 8, 1954

Time	Wind		Visibility	Temperature Dry bulb	Wet bulb	Dew point	Vapour pressure	Weather and cloud
	°	kt.	miles	°F.	°F.	°F.	mb.	
0600	170	15	12½	30	...	27	...	Fine after a shower; 1 okta large Cu
1200	260	8	5	33	...	31	...	Cloudy after snow in the past hour; 4 oktas Sc at 1,500 ft., 2 oktas at 800 ft., some Ci
1353	270	7	30	32·6	31·3	29	5·5	1 okta Cu at 2,000 ft.
1451	310	4	30	29·7	28·5	26	4·7	1 okta Cu at 2,500 ft.
			yd.					
1520	Calm		200	26·0	...	...	...	No cloud
1545	Calm		80	20·2	...	...	...	Sky obscured
1556	Calm		80	19·2	19·1	17	3·3	Sky obscured
1640	Calm		200	13·9	...	...	...	2 oktas Sc at 3,000 ft.
			miles					
1654	210	5	2½	18·2	18·0	16	3·1	5 oktas Sc at 3,000 ft.
1710	Calm		15	30·1	...	...	...	No cloud

Depth of snow at 1153: 5 in. Temperature in snow at 1615: 18°F.
Depth of snow at 1757: 4 in. Minimum temperature read at 1800: 14°F.

The above description summarizes information given in two letters by Mr. H. Gillett of the Meteorological Office, Stornoway airport. Dew points, vapour pressures and the 0600 and 1200 observations have been added.

Mr. E. K. Wade, the Air Traffic Control Officer at Stornoway on the day in question, states that during most of the duration of the fog it was possible to look out over the top of the fog from his station in the control tower but that he was occasionally just in it. This confirms a height of 15–20 ft. and occasionally more for the fog.

[The observations reported by Mr. Gillett and Mr. Wade are very remarkable. Without fuller information about the temperature at the surface of the snow and within the snow it is difficult to examine the phenomena quantitatively.

The "steaming" in the lowest 2 ft. over the snow observed from 1200 onwards appears to have been a thin mist forming in relatively warm damp air being cooled over the cold snow analogous to the very low-level mist which may form just over the grass early on calm radiation nights.

Mist formation over snow is well known to be possible with the onset of a warmer damper air mass than the one from which the snow fell, but no record of mist over newly fallen snow was noted in some papers on fog over snow that have been consulted. The snow temperature on this occasion was perhaps unusually low in comparison with the surface air temperature. The upper air temperatures observed over Stornoway by radio-sonde on February 8 are given in Table II.

TABLE II—UPPER AIR TEMPERATURES AT STORNOWAY, FEBRUARY 8, 1954

Pressure	0200 G.M.T. Height	0200 G.M.T. Dry bulb	0200 G.M.T. Dew point	1400 G.M.T. Height	1400 G.M.T. Dry bulb	1400 G.M.T. Dew point
mb.	ft.	°F.	°F.	ft.	°F.	°F.
600	12,560	−12	−28	12,650	−17	−28
700	8,850	−2	−14	8,950	−1	−10
800	5,550	10	2	5,630	12	6
850	4,020	16	9	4,090	18	12
900	2,560	22	17	2,620	25	18
Surface	...	31	24	...	31	28

Isothermal layers.—At 0200: −12°F. from 627 mb. (about 11,500 ft.) to 600 mb. (12,560 ft.)
At 1400: −18°F. from 590 mb. (about 13,000 ft.) to 580 mb. (about 13,400 ft.)

It would be a difficult problem to estimate quantitatively the temperature at the surface in the sunshine supposing the temperature at 2 in. was 18°F., taking account of the net outgoing long-wave radiation, the incoming short-wave sun and sky radiation (which penetrates an appreciable distance into new loose snow), conduction of heat within the snow, and the gains, small in the calm conditions, of heat (including latent heat of condensation from water vapour) diffused down from the atmosphere. It does not, however, seem likely that the surface temperature can have much exceeded the temperature at 2 in. The following calculation of the net outgoing long-wave radiation and the insolation suggests there was little, if any, heating of the surface by radiation even at midday. The net outgoing long-wave radiation from the surface is about a quarter of the black-body radiation appropriate to the surface temperature* which gives, for a temperature of 18°F., a net loss of 0·1 gm. cal./cm.^{2}/min. From the Smithsonian Meteorological Tables† it appears that the total incoming sun and sky radiation on a horizontal surface at midday (sun's elevation 17°) at Stornoway on February 8 was about 0·45 gm. cal./cm.^{2}/min., but, taking the albedo of new snow as at least 80 per cent., less than 0·1 gm. cal./cm.^{2}/min. would be available for absorption by the snow. A higher temperature than 18°F. would make the radiation balance less favourable. It will be seen that the screen temperature fell between 1353 and 1451. If the surface temperature was 18°F. there was, before the onset of the thick fog, a fall of vapour pressure of 1·5–2 mb. from screen level to the snow surface.

The fog which formed when the aircraft violently stirred up much snow at 1457 seems to have been produced by rapid enforced mixing of the cold air near the surface with warmer damper air above and, perhaps, by cooling of the air by the cold snow thrown into it.

The fall of screen temperature to below 14°F. at 1640 is very remarkable. Possibly much of the snow was at a temperature below 18°F. Radiation from the fog may have contributed.

*BRUNT, D.; Physical and dynamical meteorology. 2nd edn, Cambridge, 1939, p. 128.
†Washington D.C., Smithsonian Institution. Smithsonian meteorological tables. *Smithson. misc. coll., Washington D.C.*, **114**, 6th revised edn, 1951, Table 149.

It has been verified that no salt or other freezing-point reducing agents were used. The fact that the snow was melting on roofs at 10 ft. or above does not imply the air temperature at that level was above freezing point.—Ed., *M.M.*]

Atmospheric electricity and jet streams

During fair weather, a positive atmospheric potential gradient averaging about 130 v./m. is normally observed near the surface. Large positive or negative fluctuations are produced by various weather phenomena such as precipitation, fog and duststorms. Fluctuations occur also, however, during fair weather, and a report* based on observations at Albany, New York, suggests that high positive values may be associated with the proximity of jet streams.

To investigate this theory, records and data from Lerwick Observatory were utilized, Lerwick being chosen because of its freedom from smoke pollution and the proximity of a radar-wind station. A correlation coefficient was first obtained between the electrograph readings and the wind speed at 300 mb. measured four times daily. Omitting all occasions of precipitation, fog and very low cloud, the value obtained over a period of five months was −0·06.

A fuller investigation was then made for the period April–September 1953. All the occasions were extracted when, for a period of two hours or more, the electrograph trace had a positive deflexion exceeding 5 mm., this deflexion representing a positive potential gradient of about 225–275 v./m. Occasions when a jet axis was located within 50, 100 and 200 miles of Lerwick were tabulated using the charts at the Central Forecasting Office, a jet stream being defined as a wind maximum of 80 kt. or more at 300 mb. High potential gradient and jet-stream proximity were taken as coinciding if they occurred on the same day. As before, days when the recordings were considered to have been affected by precipitation, etc., were excluded. The following results were obtained:—

Number of days of high potential gradient	33
Number of these days with jet axis within 50 miles ...	4 (3)
Number of these days with jet axis within 100 miles ...	4 (5)
Number of these days with jet axis within 200 miles ...	11 (8)
Total number of days with jet axis within 50 miles ...	14
Total number of days with jet axis within 100 miles ...	20
Total number of days with jet axis within 200 miles ...	35

146 days were considered, and the figures in brackets are the frequencies to be expected with no correlation.

The results may not be exact, owing to the difficulty occasionally of determining the position and velocity of a jet stream, and to the fact that only the 300-mb. level was considered. It would certainly appear, however, that the Lerwick observations show no significant correlation between surface potential gradient and the proximity of jet streams.

P. GRAYSTONE

*FALCONER, R. E.; A correlation between atmospheric electrical activity and the jet stream. *Rep. Gen. Elect. Res. Lab., Schenectady N.Y.*, No. RL-900, 1953.

Pressure changes associated with supersonic bangs

Mr. G. Slavin of the Veterinary Laboratory (Ministry of Agriculture and Fisheries) at Weybridge, Surrey, has drawn attention to the barogram reproduced in the lower photograph facing p. 337 which recorded the occurrence of supersonic bangs at about 1550 on April 1, 1954.

The bangs were very loud but the barograph was not inspected until an hour later when the kicks in the trace were first noticed. The horizontal lines on the barogram are at intervals of pressure of 0·5 mm. of mercury, so that the pressure suddenly rose about 1·3 mm. and fell again about 0·8 mm. of mercury, giving a total amplitude of pressure change equivalent to about 2·8 mb.

The barograms at Kew and London Airport showed no similar traces of sudden changes; even the very sensitive microbarograph at Kew Observatory showed no trace during the afternoon of April 1.

REVIEW

Climatic change: evidence, causes and effects. Edited by Harlow Shapley. 8½ in × 6½ in., pp. xiv + 318, *Illus.*, Harvard University Press, Cambridge Mass., London: Geoffrey Cumberlege, 1953. Price \$6 or 48*s.*

This handsome volume brings together 22 papers read at a two-day conference organized by the American Academy of Arts and Sciences in May 1952. The contributions deal with all aspects of the problem, but interest is concentrated mainly on the Quaternary Ice Age and subsequent oscillations of climate. The recurrent theme is that climatic changes, of whatever length, can only be due to changes of solar radiation. The effects of orogeny, continentality and ocean currents are relegated to a minor place, while D. Brouwer dismisses continental drift and pole movements very shortly. Thus H. C. Willett argues that climatic history shows a whole spectrum of cycles of lengths from 10,000 yr. down to the sunspot cycle, all of which are essentially similar, and must therefore result from cycles of solar radiation acting through changes in the atmospheric circulation. Topography only comes in to the extent that mountains may be necessary as gathering grounds for glaciers. Even the Permo-Carboniferous ice sheets of tropical regions are attributed by J. Wohlbach to changes of solar radiation acting on a peculiar topography.

The difficulty that solar changes should theoretically be most effective at the equator while temperature changes are greatest in high latitudes, is overcome in various ways. H. Wexler finds that, owing to their effect on pressure centres, storm tracks and cloudiness, changes of solar radiation are most effective in latitudes 40–50° in winter and 65–70° in summer. D. H. Menzel associates ice ages with irregularities in the ion clouds coming from the sun, causing intense local heating in the auroral zone and increased numbers of condensation nuclei, though he remarks that the latter effect could also be produced by volcanic dust. The most consistent contribution along these lines is that of B. Bell, based on Willett's modification of Simpson's theory. The gradual cooling and desiccation during the Tertiary are attributed to steadily decreasing radiation; this was followed during the Quaternary by a series of oscillations, each glacial period coming during a period of increasing radiation while the seas were still cold and there were floating polar ice caps. Changes in the positions of the centres of glaciation may have been due to shifts of the magnetic pole, through their steering effect on solar corpuscular emissions.

Going back one step further, the cause of the variations of solar radiation is still obscure. The effect of changes in the earth's orbit and its axis of rotation is ruled out by A. J. J. van Woerkom, who gives revised insolation curves bearing little relation to the sequence of glacial periods. There remain the fascinating theory of E. J. Öpik, summarized by P. L. Bhatnagar, which relates variations in the luminosity of a star to a convective cycle of thermonuclear processes involving the conversion of hydrogen into helium, and the ideas of Hoyle and Lyttleton, presented by M. Krook, that ice ages are due to the passage of the sun through clouds of interstellar matter.

The last ten papers deal with various lines of evidence as to climatic changes in geological and recent times. R. F. Flint gives some new material on glacial and post-glacial oscillations of North American ice sheets, to which J. L. Kulp adds the results of radio-carbon dating of deposits in Bermuda. E. Schulman summarizes the dated evidence of tree rings in the Colorado River basin back to 58 B.C., and J. H. Conover discusses the interpretation of instrumental climatic data. E. S. Barghoorn gives some interesting inferences from fossil plants, remarking that the climatic change which culminted in the Pleistocene began twenty million years earlier. E. H. Colbert deals similarly with vertebrates. Finally, E. S. Deevey, Jr. in a long richly documented paper (176 references) brings together the evidence from fossil lakes, especially in western North America and east Africa.

The first three papers (which surely should have been the last three) deal with the effects of climatic changes—H. Shapley on climate and life, C. S. Coon on climate and race, and P. B. Sears on climate and civilization. The last-named, in opposition to Huntington, considers that cultural deterioration and expansion of deserts are due more to pressure of population, causing destruction of forests and soil erosion, than to changes of climate.

The general impression left by the book is one of intense interest and activity in a subject which calls for the co-operation of workers in many different branches of science. The preoccupation with solar cycles is probably only the latest, not the last, of the long succession of "solutions" which began in 1875 with Croll's "Climate and time", but every attempt must bring nearer the real and final solution. The problem is one of real importance; the last half-century has shown that climatic changes are not merely of academic interest as a fertile field for speculation, but will most likely have a practical bearing on the future of man.

C. E. P. BROOKS

SPECIAL PROMOTION ON MERIT

In 1953 Dr. G. D. Robinson, Superintendent of Kew Observatory, became the first member of the Meteorological Office to be awarded promotion on the grounds of special merit. This year it is a pleasure to announce that another member of the Meteorological Office staff, Dr. F. Pasquill, has been promoted to Senior Principal Scientific Officer on the recommendation of the Interdepartmental Scientific Panel, again in recognition of exceptional ability in research.

Dr. Pasquill graduated at Durham in 1935 with first class honours in physics. He spent the next two years in research on the electrification of rain under the direction of Dr. J. A. Chalmers, after which he entered the Meteorological

Office, being posted to the Meteorology Section of the Chemical Defence Experimental Station at Porton. Here he found congenial work in the experimental and instrumental aspects of micrometeorology. Using one of the wind tunnels available in the Meteorology Section, he spent much time in a painstaking study of evaporation from plane free-liquid surfaces into a turbulent air stream, and in 1943 he published in the *Proceedings of the Royal Society* what is now recognized as a major contribution to this problem. By taking full account of the aerodynamic factors and by precise and ingenious experimentation, Dr. Pasquill succeeded, for the first time, in bringing order into this subject, and it is probably fair to say that since the publication of this study it has not been worth while for anyone to repeat the investigation. He also extended the wind-tunnel work to small-scale experiments in the open.

In 1943 he left for Australia to conduct investigations into micrometeorological problems in semitropical conditions, and on his return to the United Kingdom in 1946 he was posted to the School of Agriculture, Cambridge, for studies on the application of meteorology to problems arising in farming. During the next four years he published five notable papers dealing with transfer problems near the ground, and thereby provided a basis for a workable method of estimating the flux of water vapour into the air from natural surfaces. This work again was distinguished by meticulous care in the experimentation. These studies received recognition in 1950 by the double award of the degree of D.Sc. (Durham) and the L. G. Groves Memorial Prize for Meteorology.

From 1949 to 1954 Dr. Pasquill has been stationed at the Atomic Energy Research Establishment, Harwell, where he has extended his work on diffusion to problems relating to the spread of radioactive effluent from an atomic pile. For this purpose he has been attached to the Health Physics Division and has contributed much to the solution of their extremely important problems. He is also a member of the Atmospheric Pollution Research Committee.

Dr. Pasquill will now return to the Chemical Defence Experimental Station, Porton.

METEOROLOGICAL OFFICE NEWS

Academic successes.—To the lists published in the October number should be added:—

General Certificate of Education (Advanced Level).—Pure and applied mathematics and physics, C. D. Kemshall, R. F. Scarsbrook.

City and Guilds.—Mathematics III, J. W. O. Rowe.

Ocean weather ships.—The following extracts from the report of the Meteorological Officer-in-Charge aboard o.w.s. *Weather Recorder*, Voyage 54, at ocean weather station JULIETT illustrate the unusual and interesting natural phenomena which may sometimes be observed aboard an ocean weather ship:—

The aurora, somewhat unexpectedly, was seen on four occasions.

On August 10, a large fish some 4–5 ft. across, in an exhausted condition seen close to the ship was identified as a sun fish. A second fish believed to be of the same species was seen at about 54°N. 13°W. on the homeward passage. A small blue shark about 4–5 ft. long was seen swimming around the ship for about 3 hr. on August 19. Attempts were made to catch it without success. These visitors from tropical waters were unexpected. Sea temperatures were, if anything, lower than normal at about 57°F. although during the time the shark was seen the temperature of the sea surface layer rose by some 3–4°F. to 60–61°F. in calm conditions.

WEATHER OF SEPTEMBER 1954

Mean pressure was below normal over Scandinavia, north France, Belgium, Holland and Germany; the greatest deficit of pressure, 10–11 mb., occurred over Norway and Sweden and the lowest mean pressure, 997 mb., occurred between Norway and Iceland. Mean pressure over the rest of Europe was generally 1–2 mb. above normal and the mean pressure at the Azores, 1025 mb., was 2 mb. above normal. This mean pressure distribution gave a marked gradient for south-westerly winds over much of Europe. The mean pressure over the United States was generally 2 mb. below normal.

The mean temperature was about 2–3°F. above normal over the greater part of Europe except at places in north France, Belgium and north Germany where it was a little below normal. Over most of the United States (south of 45°N.) mean temperature was generally 3–4°F. above normal.

In the British Isles the changeable weather of the preceding three months continued through September. On nearly every day a substantial part of the country was affected by cyclonic systems moving from the Atlantic and the few intervening ridges of high pressure were weak and transitory. Winds were frequently from a westerly point and reached gale force at intervals in association with the more vigorous depressions. Temperature was for the most part below the average but, in marked contrast to the previous three months, sunshine appreciably exceeded the average in many areas. It was very wet in some western districts but drier than usual in eastern England.

The very warm weather of August 31 continued over the following day; Southport, with a maximum temperature of 81°F., had its warmest September day since 1906 and at places in east and south-east England 11–12 hr. sunshine were recorded. In Scotland and Ireland the month opened with mainly cloudy weather and rain in places. This type of weather spread south-east on the 2nd and was accompanied in England and Wales by a fall of temperature amounting to some 10°F. No really warm weather occurred during the rest of the month. On the 3rd a depression moved from south-west Ireland to a position off south-west Norway giving a gale locally in the Irish Sea. On the 9th another depression followed a similar path and on the 10th a wave depression moved quickly across southern England to the North Sea; gales occurred at exposed stations in the west and rainfall was heavy in places, for example 2·61 in. at Borrowdale, and 2·24 in. at Watendlath Farm, Cumberland on the 9th and 1·36 in. at Lake Vyrnwy on the 10th. On the 14th an Atlantic depression moved east-north-east to north-west Scotland and later north-east to west Norway; considerable rain fell in northern districts (2·08 in. at Watendlath Farm on the 15th and 1·85 in. at Lerwick, Shetland Islands on the 16th) and strong westerly winds and local gales were recorded on the 16th. An intense depression moved to north-west of Scotland on the 23rd and thence to the northern North Sea, while troughs of low pressure crossed the British Isles; rain occurred generally and was heavy in places (2·00 in. at Liskeard, Cornwall and at Sheepstor, Devon and 2·04 in. at West Baldwin, Isle of Man) and winds were strong to gale force locally. Though there were periods of continuous rain in many parts of the country much of the rainfall of the month fell as showers and there were considerable sunny intervals in between. Thunderstorms occurred in places on numerous days, chiefly in the second and third weeks. Distinctly colder weather spread southward over Scotland on the 26th and extended to the whole country during the 28th and 29th. Snow fell on the Scottish hills in the last week and sleet locally at lower levels in the north of Scotland on the 28th–30th. Ground frost occurred in widely separated areas in the early morning in the latter part of the month and a screen minimum of 23°F. occurred at Eskdalemuir on the 27th and 28th.

The general character of the weather is given by the following provisional figures:—

	AIR TEMPERATURE			RAINFALL		SUNSHINE
	Highest	Lowest	Difference from average daily mean	Percentage of average	No. of days difference from average	Percentage of average
	°F.	°F.	°F.	%		%
England and Wales ...	87	24	−1·5	138	+8	119
Scotland	77	23	−2·2	156	+7	105
Northern Ireland ...	71	28	−2·0	162	−9	112

RAINFALL OF SEPTEMBER 1954

Great Britain and Northern Ireland

County	Station	In.	Per cent. of Av.	County	Station	In.	Per cent. of Av.
London	Camden Square	1·76	97	*Glam.*	Cardiff, Penylan	6·92	227
Kent	Dover	1·51	65	*Pemb.*	Tenby, The Priory	3·72	118
,,	Edenbridge, Falconhurst	2·59	114	*Radnor*	Tyrmynydd	6·53	169
Sussex	Compton, Compton Ho.	4·30	154	*Mont.*	Lake Vyrnwy	8·21	227
,,	Worthing, Beach Ho. Pk.	2·51	117	*Mer.*	Blaenau Festiniog	12·49	159
Hants.	Ventnor Cemetery	3·64	143	,,	Aberdovey	4·74	148
,,	Southampton, East Pk.	3·06	140	*Carn.*	Llandudno	2·48	116
,,	South Farnborough	2·17	114	*Angl.*	Llanerchymedd	5·45	185
Herts.	Royston, Therfield Rec.	1·29	69	*I. Man*	Douglas, Borough Cem.	6·23	191
Bucks.	Slough, Upton	2·03	115	*Wigtown*	Newton Stewart	7·23	212
Oxford	Oxford, Radcliffe	2·60	152	*Dumf.*	Dumfries, Crichton R.I.	5·78	213
N'hants.	Wellingboro' Swanspool	2·18	121	,,	Eskdalemuir Obsy.	8·77	237
Essex	Shoeburyness	0·98	59	*Roxb.*	Crailing	2·20	108
,,	Dovercourt	1·37	77	*Peebles*	Stobo Castle	4·41	175
Suffolk	Lowestoft Sec. School	1·29	66	*Berwick*	Marchmont House	3·39	141
,,	Bury St. Ed., Westley H.	1·46	73	*E. Loth.*	North Berwick Res.	2·61	125
Norfolk	Sandringham Ho. Gdns.	2·63	127	*Midl'n.*	Edinburgh, Blackf'd. H.	3·41	166
Wilts.	Aldbourne	3·35	167	*Lanark*	Hamilton W. W., T'nhill	6·02	225
Dorset	Creech Grange	4·20	153	*Ayr*	Colmonell, Knockdolian	5·35	154
,,	Beaminster, East St.	4·86	191	,,	Glen Afton, Ayr San.	9·46	243
Devon	Teignmouth, Den Gdns.	2·29	117	*Renfrew*	Greenock, Prospect Hill	8·38	187
,,	Ilfracombe	5·59	208	*Bute*	Rothesay, Ardencraig	8·85	219
,,	Princetown	9·99	195	*Argyll*	Morven, Drimnin	8·58	152
Cornwall	Bude, School House	3·40	132	,,	Poltalloch	9·61	210
,,	Penzance, Morrab Gdns.	4·91	168	,,	Inveraray Castle	11·16	174
,,	St. Austell	4·83	151	,,	Islay, Eallabus	8·47	203
,,	Scilly, Tresco Abbey	3·21	125	,,	Tiree	8·52	230
Somerset	Taunton	2·54	128	*Kinross*	Loch Leven Sluice	4·47	174
Glos.	Cirencester	3·88	176	*Fife*	Leuchars Airfield	2·09	108
Salop	Church Stretton	2·34	111	*Perth*	Loch Dhu	11·54	201
,,	Shrewsbury, Monkmore	1·59	98	,,	Crieff, Strathearn Hyd.	3·93	137
Worcs.	Malvern, Free Library	1·39	72	,,	Pitlochry, Fincastle	3·40	135
Warwick	Birmingham, Edgbaston	1·69	94	*Angus*	Montrose, Sunnyside	2·35	118
Leics.	Thornton Reservoir	1·90	105	*Aberd.*	Braemar	2·86	114
Lincs.	Boston, Skirbeck	2·33	132	,,	Dyce, Craibstone	1·31	54
,,	Skegness, Marine Gdns.	2·00	110	,,	New Deer School House	2·63	104
Notts.	Mansfield, Carr Bank	2·98	162	*Moray*	Gordon Castle	2·08	83
Derby	Buxton, Terrace Slopes	5·84	180	*Nairn*	Nairn, Achareidh	2·16	102
Ches.	Bidston Observatory	2·22	92	*Inverness*	Loch Ness, Garthbeg	3·62	117
,,	Manchester, Ringway	3·35	148	,,	Glenquoich	12·30	142
Lancs.	Stonyhurst College	7·14	187	,,	Fort William, Teviot	10·55	165
,,	Squires Gate	5·26	194	,,	Skye, Broadford	10·77	156
Yorks.	Wakefield, Clarence Pk.	1·82	114	,,	Skye, Duntuilm	5·17	112
,,	Hull, Pearson Park	2·30	134	*R. & C.*	Tain, Mayfield	2·33	102
,,	Felixkirk, Mt. St. John	2·01	110	,,	Inverbroom, Glackour	6·50	147
,,	York Museum	1·82	112	,,	Achnashellach	11·65	169
,,	Scarborough	1·42	79	*Suth.*	Lochinver, Bank Ho.	4·49	129
,,	Middlesbrough	1·46	88	*Caith.*	Wick Airfield	2·74	110
,,	Baldersdale, Hury Res.	5·26	205	*Shetland*	Lerwick Observatory	6·41	213
Norl'd.	Newcastle, Leazes Pk.	2·84	143	*Ferm.*	Crom Castle	4·90	176
,,	Bellingham, High Green	4·96	207	*Armagh*	Armagh Observatory	4·39	178
,,	Lilburn Tower Gdns.	3·06	130	*Down*	Seaforde	5·00	182
Cumb.	Geltsdale	5·91	211	*Antrim*	Aldergrove Airfield	2·75	111
,,	Keswick, High Hill	10·33	244	,,	Ballymena, Harryville	4·63	149
,,	Ravenglass, The Grove	6·12	182	*L'derry*	Garvagh, Moneydig	5·00	168
Mon.	A'gavenny, Plâs Derwen	3·02	118	,,	Londonderry, Creggan	5·55	168
Glam.	Ystalyfera, Wern House	10·14	232	*Tyrone*	Omagh, Edenfel	4·95	162

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