ANALYSIS OF VISUAL AURORAL OBSERVATIONS AT HALLEY BAY, 1963

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ABSTRACT. A brief statistical analysis of the visual auroral observations carried out at Halley Bay during the winter of 1963 is given. The frequency of occurrence and the diurnal variations of the various auroral forms seen in 1963 are compared with results obtained from previous years' observations at Halley Bay. The positions of homogeneous arcs seen in 1963 are discussed and compared with the positions of homogeneous arcs during previous years.

The general conclusion is that aurorae seen from Halley Bay in 1963 follow much the same pattern as those seen during the previous three years, but there is a considerable reduction in frequency of occurrence, particularly in the case of homogeneous arcs and diffuse surfaces.

THE geographical coordinates of Halley Bay are lat. 75°31′S., long. 26°40′W. (i.e. lat. 65·8°S., long. 25·4°E. in geomagnetic coordinates); therefore the direction of the geomagnetic pole from Halley Bay is 160·9° east of true north and the magnetic dip pole is 178·5° east of true north. This also means that local midnight at Halley Bay is at 01.47 U.T. and geomagnetic midnight is at 03.03 U.T. This position is on the outer edge of the auroral region, as defined in the *International Auroral Atlas*, so most of the aurorae seen from Halley Bay occur in the southern part of the sky. In fact the whole of the "auroral region" comes within the field of view from Halley Bay.

Unfortunately there was not a full-time auroral observer at Halley Bay in 1963, as in previous years. However, regular observations were carried out by five members of the British scientific station under the supervision of M. Walford. This may have led to a certain amount of subjective error, which on the whole should not be too serious. A regular watch was kept throughout the dark hours between the times of nautical twilight (but only from 19.00 until 10.00 U.T. during the darkest months). The regular observations were made at each quarter-hour of universal time, with more frequent observations during active displays.

As with observations in previous years, the classification of auroral forms is that given in the *Photographic Atlas of Auroral Forms*. An alidade-azimuth indicator, made up from a Meteorological Office alidade and a semi-circular horizontal plate marked in degrees east of true north, was used to fix the position of the various auroral forms.

ANALYSIS OF RESULTS

Auroral observations were carried out on 207 nights during 1963. On 72 of these the sky was completely obscured by cloud or drifting snow. Aurorae were seen on 51 of the remaining nights and they reached the overhead position (i.e. an elevation greater than 60°) on 8 of these nights. This is a considerable decrease in auroral activity at Halley Bay compared with previous years. The fall in activity is also shown by the fact that of 30 nights which were clear and dark all night (and on which observations were made for more than just a few hours) 10 had no aurorae whatsoever. Thus there were aurorae on only 66·7 per cent of the clear dark nights in 1963, whereas they were seen on almost every night during the 1961 and 1962 seasons. Also, if it is assumed that overhead aurorae would be seen unless the sky was completely obscured by cloud or drift, then overhead aurorae occurred on 5·9 per cent of possible nights (cf. 24·1 per cent in 1961 and 20·1 per cent in 1962).

Table I gives the diurnal variations of the various auroral forms, using only observations made when the sky was clear and dark. Observations in each hourly period are taken as those at a quarter past, half past, a quarter to, and on the hour (the period 19.00–20.00 U.T. therefore refers to observations at 19.15, 19.30, 19.45 and 20.00 U.T.). Table II is a similar table, but using all observations irrespective of the visibility.

The individual rows in Tables I and II represent the following:

a. Number of observations.
b. Number of observations when aurorae were present.
c. Number of observations with homogeneous arcs present.
d. Number of observations with active forms present.

TABLE I. DIURNAL VARIATIONS
(Clear dark periods)

U.T.	20	21	22	23	24	01	02	03	04	05	06	07	08	09		*Totals*
a	64	92	103	118	122	135	136	142	127	110	97	80	82	49	28	1,485
b	4	2	2	22	39	46	52	78	75	64	48	37	25	5	0	499
c	2	0	2	16	26	34	39	51	45	35	25	22	9	0	0	306
d	0	0	1	4	8	16	15	16	9	11	12	7	4	0	0	103
e	0	0	0	1	5	7	6	14	11	3	6	5	4	2	0	64
f	2	2	1	4	8	2	3	4	13	17	7	5	11	3	0	82
g	0	0	2	10	8	10	10	5	2	4	1	0	0	0	0	52
																(per cent)
b′	6·2	2·2	1·9	18·6	32·0	34·1	38·2	54·9	59·0	58·2	49·5	46·2	30·5	10·2	0	33·6
c′	3·1	0	1·9	13·6	21·3	25·2	28·7	35·9	35·4	31·8	25·8	27·5	11·0	0	0	20·6
d′	0	0	1·0	3·4	6·6	11·8	11·0	11·3	7·1	10·0	12·3	8·7	4·9	0	0	6·9
e′	0	0	0	0·8	4·1	5·2	4·4	9·9	8·7	2·7	6·2	6·2	4·9	4·1	0	4·3
f′	3·1	2·2	1·0	3·4	6·6	1·5	2·2	2·8	10·2	15·4	7·2	6·2	13·4	6·1	0	5·5
g′	0	0	1·9	8·5	6·6	7·4	7·4	3·5	1·6	3·6	1·0	0	0	0	0	3·5

TABLE II. DIURNAL VARIATIONS
(Sun more than 12° below horizon)

U.T.	20	21	22	23	24	01	02	03	04	05	06	07	08	09		*Totals*
a	487	574	650	711	757	794	808	799	772	733	675	601	517	422	323	9,623
b	12	11	33	50	84	106	99	118	105	88	75	61	45	17	0	904
c	2	0	12	22	30	44	40	59	55	42	41	30	9	0	0	386
d	2	4	10	14	17	30	31	26	15	18	19	10	4	0	0	200
e	0	0	3	7	8	7	11	21	36	8	6	5	4	2	0	118
f	2	2	1	4	8	3	6	8	13	17	7	5	11	3	0	90
g	0	1	6	13	10	15	17	9	2	4	1	0	0	0	0	78
																(per cent)
b′	1·8	1·9	5·1	6·6	10·6	12·9	12·1	14·8	13·6	12·0	11·1	10·1	8·7	4·0	0	9·4
c′	0·4	0	1·8	3·1	4·0	5·5	5·0	7·4	7·1	5·7	6·1	5·0	1·7	0	0	4·0
d′	0·4	0·7	1·5	2·0	2·2	3·8	3·8	3·3	1·9	2·5	2·8	1·7	0·8	0	0	2·1
e′	0	0	0·5	1·0	1·1	0·9	1·4	2·6	4·7	1·1	0·9	0·8	0·8	0·5	0	1·2
f′	0·4	0·3	0·2	0·6	1·1	0·4	0·8	1·0	1·7	2·3	1·0	0·8	2·1	0·7	0	0·9
g′	0	0·2	0·9	1·8	1·3	1·9	2·1	1·1	0·3	0·5	0·1	0	0	0	0	0·8

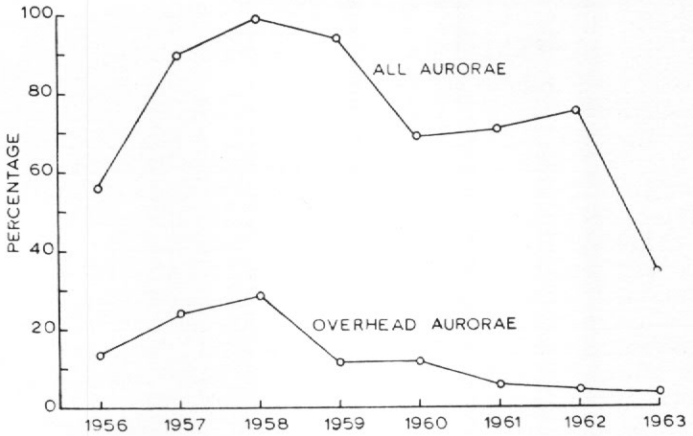

Fig. 1. Occurrence of all aurorae and overhead aurorae, 1956–63.

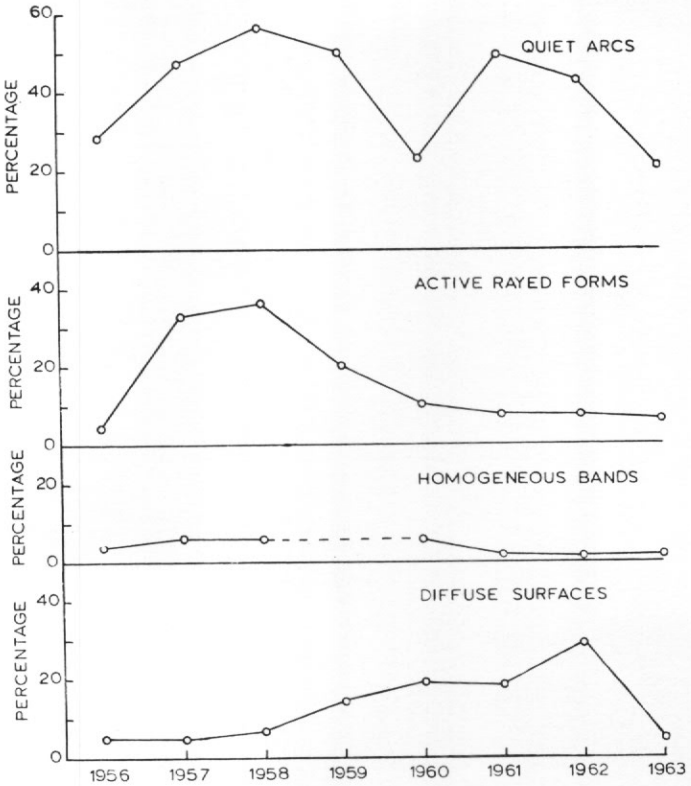

Fig. 2. Occurrence of various auroral forms, 1956–63. Values for active forms and diffuse surfaces in 1959 are for all clear periods, including moonlit periods; in 1959 the active forms also include homogeneous bands.

e. Number of observations with diffuse surfaces present.
f. Number of observations with glows present.
g. Number of observations when the aurorae were overhead.

Rows *b'*, *c'*, etc., are the respective percentage frequencies, using the figures in row *a* of each table. The last column in each table gives the total number of the various forms seen throughout the year, and the respective percentage frequencies of occurrence (based on row *a*).

In the above groupings the active forms in row *d* refer to rayed bands, homogeneous bands, rayed arcs, coronae, isolated rays or bundles of rays, and multiple arcs; and row *e* (diffuse surfaces) includes the form where rays and diffuse surfaces intermingle in the sky.

In Fig. 1 the percentage frequencies of occurrence of all aurorae and overhead aurorae, occurring on clear dark nights in 1963 (as given in the last column of rows *b'* and *g'* in Table I) are compared with the frequencies of occurrence during previous years at Halley Bay. This again shows a considerable drop in auroral activity, although there appears to be about the same frequency of occurrence of overhead aurorae as during the previous two years.

A similar comparison for homogeneous arcs, active forms and diffuse surfaces is made in Fig. 2. The active forms are divided into rayed active forms and homogeneous bands (including multiple arcs). Rayed active forms occurred in 89 (6·0 per cent) observations when the sky was clear and dark, and homogeneous bands in 19 (1·3 per cent) observations. From Fig. 2 it can be seen that there has been very little change in the frequency of occurrence of active forms during the past three or four years. It should be noted that overhead aurorae at Halley Bay are usually of an active form, so that it is not surprising that (as can be seen in Fig. 1) there has been little change in the frequency of occurrence of overhead aurorae during the last few years. However, as can be seen from Fig. 2, there was a considerable drop

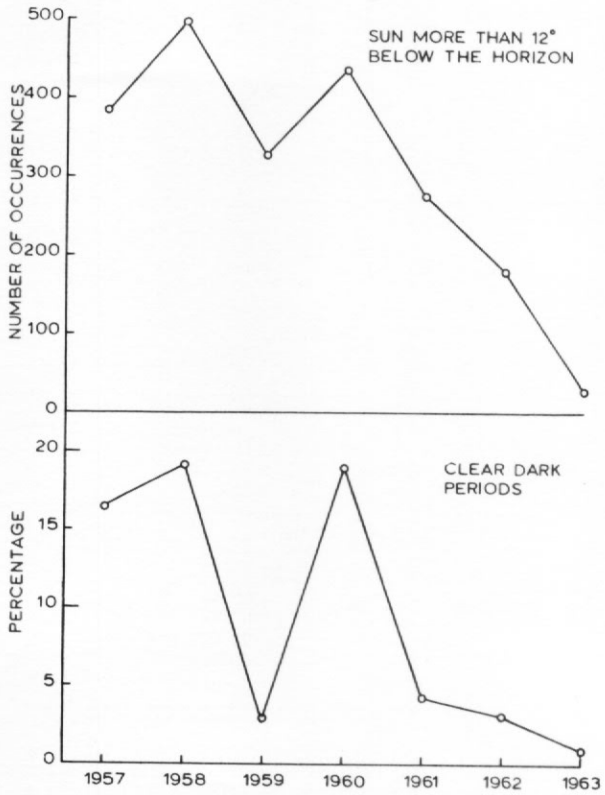

Fig. 3. Occurrence of flaming, 1957–63.

in the frequencies of occurrence of both homogeneous arcs and diffuse surfaces in 1963. This, more than anything else, probably accounts for the reduction in frequency of occurrence of all aurorae as shown in Fig. 1.

There was also a considerable reduction in the frequency of occurrence of flaming in 1963; this phenomenon was seen on only 28 occasions in 1963, and on 14 occasions (0·9 per cent) when the sky was clear and dark. Fig. 3 shows these figures in comparison with those obtained at Halley Bay from previous years' observations.

The number of occurrences of red type A for the years 1956 to 1963 is plotted in Fig. 4. Red coloration was seen on 23 occasions in 1963 and, as no reference was made to its occurrence as a lower border, these are all assumed to be red type A (although it is possible that two or three of the occurrences on 22–23 September were red type B).

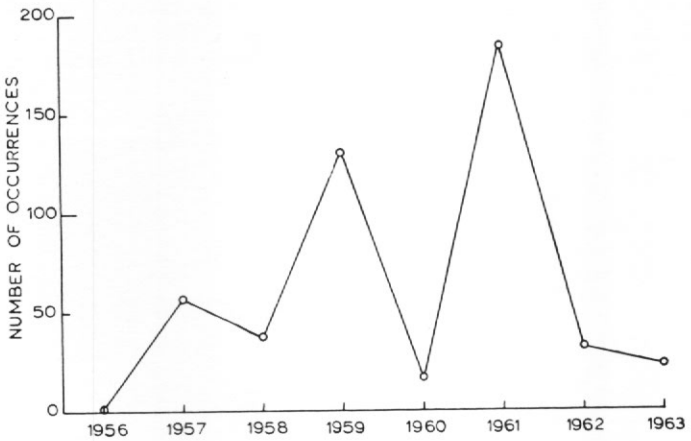

Fig. 4. Occurrence of red type A, 1956–63.

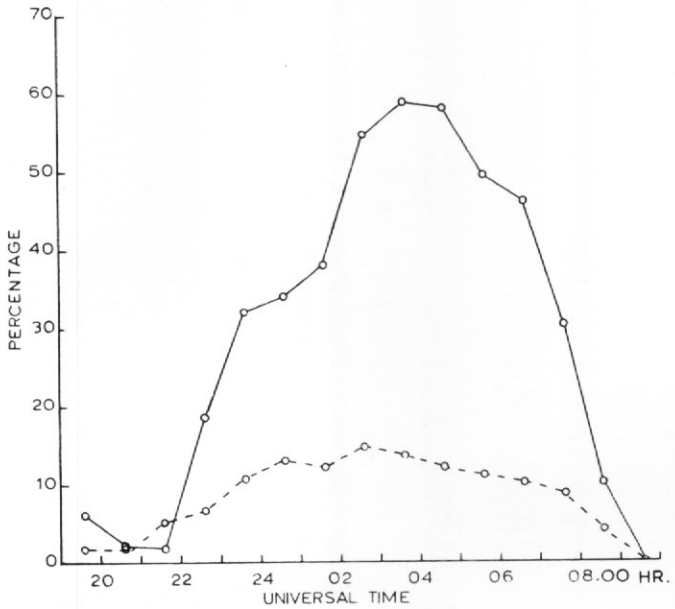

Fig. 5. Diurnal variation of all aurorae.

All the values from previous years' results have been obtained either from the original report sheets (in the case of flaming) or from the following sources: 1956, 1957 and 1958 from Evans and Thomas (1960), 1959 from Sheret (1963), 1960 from Blackie (1964) and 1961 and 1962 from the author's own observations (Blundell, in press).

The diurnal variations of the various forms, as given in Tables I and II, are plotted as percentages in Figs. 5 to 10. In these figures the full lines represent the percentage frequency of occurrence in clear dark periods and the broken lines represent the percentage frequency of occurrence when the Sun was more than 12° below the horizon.

Fig. 5 suggests that the maximum frequency of occurrence of all aurorae seen from Halley Bay in 1963 occurred near geomagnetic midnight (the results for clear dark periods give a maximum just after geomagnetic midnight, and those for all conditions with the Sun 12° below the horizon give a maximum just before geomagnetic midnight). This is in good agreement with previous years' results, which gave maxima at or just after geomagnetic midnight (Blackie, 1964; Blundell, in press; Evans and Thomas, 1960; Sheret, 1963). In the case of aurorae which are overhead at Halley Bay (Fig. 6), there was a broad maximum in 1963

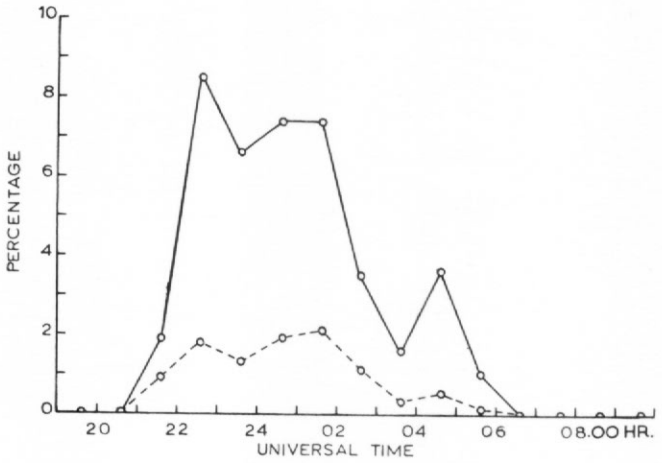

Fig. 6. Diurnal variation of overhead aurorae.

from 22.00 to 02.00 U.T., which is much earlier than it had been in previous years (Blackie, 1964; Blundell, in press; Evans and Thomas, 1960; Sheret, 1963).

The distribution of active forms shown in Fig. 7 suggests a bimodal distribution of the forms throughout the night with maxima at about local midnight and at 04.00 local time (approximately 06.00 U.T.). Previous years' results had suggested one maximum at about geomagnetic midnight (Blackie, 1964; Blundell, in press; Evans and Thomas, 1960; Sheret, 1963), although there was some suggestion of a bimodal distribution in 1961. Although there was about the same percentage frequency of occurrence of active forms in 1963 as there had been during the previous two years, the diurnal variation of these forms was somewhat different in 1963.

In the case of diffuse surfaces, the diurnal variation in 1963 appears to have been somewhat different from that of previous years, with a maximum frequency in 1963 at about geomagnetic midnight (Fig. 8) instead of the gradual increase in frequency throughout the night which had been a feature of the displays at Halley Bay during previous years (except during 1956 when there was a maximum just after geomagnetic midnight). There was a gradual increase in the percentage frequency of occurrence of these forms from 1958 until 1962 (Fig. 2), but there now appears to be a return to the same percentage frequency of occurrence and the same diurnal variation as there had been in 1956. Both diurnal variations (for 1956 and 1963) show maxima near geomagnetic midnight, and a higher frequency of occurrence after geo-

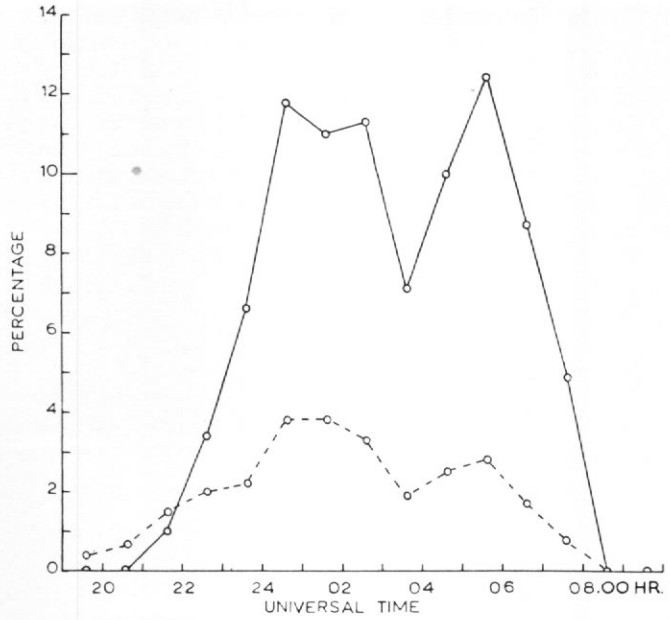

Fig. 7. Diurnal variation of active forms.

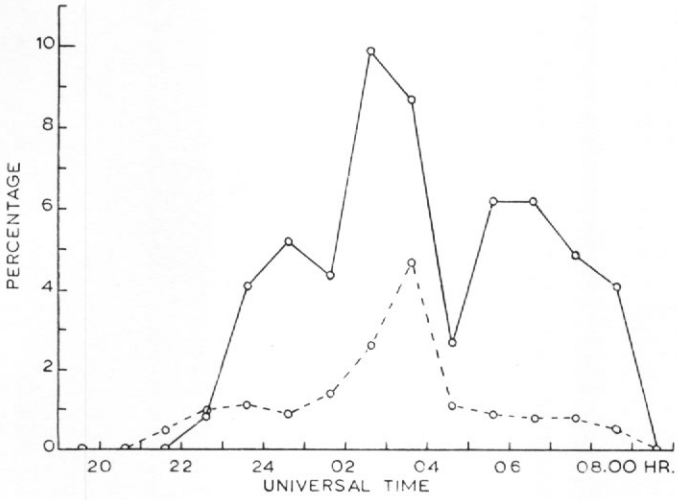

Fig. 8. Diurnal variation of diffuse surfaces.

magnetic midnight than there had been during the evening; in fact during both years no diffuse surfaces were seen in clear dark periods before 22.00 U.T.

In the present classification of auroral forms, as given by Störmer (1930), those classified as glows include two different kinds of auroral light:

i. Auroral light near the horizon and probably the upper part of a more definite form which is just below the horizon.

ii. The faint light which on occasions covers a considerable part of the sky, and which is described as "a veil" in the new *International Auroral Atlas* (Paton and Jacka, 1963).

Under the present system of classification it is not possible to tell from the report sheets to which of these two forms the term "glow" refers. This problem should be solved in future years with the introduction of the new classification (Paton and Jacka, 1963), which is being used for the first time in 1964. There appears to be a considerable difference in the diurnal variations of glows during the years since 1960, when they were first analysed in detail. This may, however, be due to subjective error, because of the faintness of these forms. Evidence of this possible subjective error is the fact that in 1961 and 1962 the diurnal variations were very similar (Blundell, in press), when observations were made by the same observer. It seems likely that the differences between the diurnal variations in these two years and those of 1960 (Blackie, 1964) and 1963 (Fig. 9) are due to the observations being done by different people.

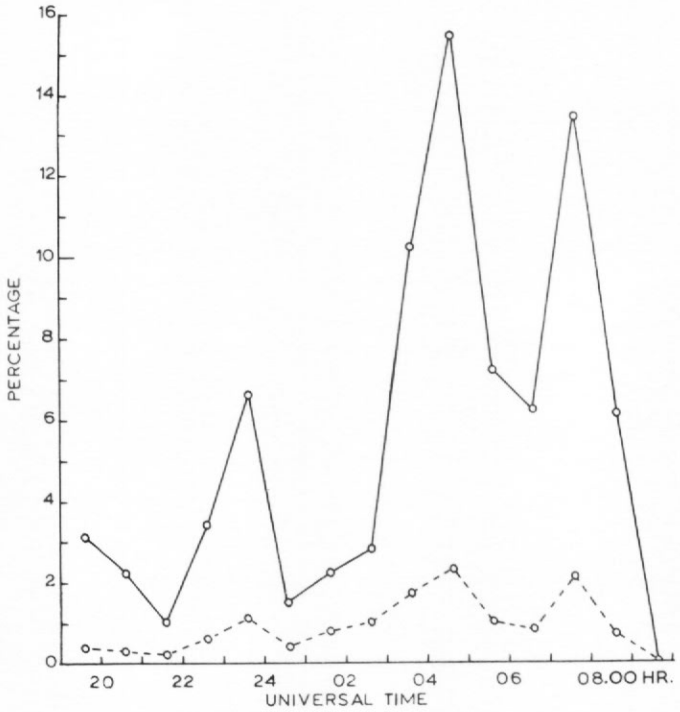

Fig. 9. Diurnal variation of glows.

The diurnal variation of the distribution of homogeneous arcs for 1963 (Fig. 10) is very similar to that for 1960 (Blackie, 1964), the last year during which there was roughly the same percentage frequency of occurrence of homogeneous arcs as in 1963 (Fig. 2). This provides support for the argument put forward by Blundell (in press) that there is a basic arc zone with a distribution similar to that of 1960, and that during some years there is an increase in homogeneous arcs at certain times of the night.

The latitude position of homogeneous arcs (assuming a height of 100 km.) is given in Table III, and Fig. 11 shows the histograms for the distribution of homogeneous arcs against geomagnetic latitude and azimuth (only arcs with a sharp lower border are used for these measurements). The median latitude of homogeneous arcs during 1963 was lat. 71·2°S. geomagnetic and the interquartile range was from lat. 70·5° to 72·3°S. geomagnetic. The mean azimuth was 165·2° east of north and the median azimuth was 161·5° east of north with an interquartile range from 160° to 170·5° east of north. In Fig. 12 both the median latitude and the median azimuth are compared with those from previous years' observations at Halley Bay. Although the azimuth suggests that the position of homogeneous arcs is the same as in 1960, the median latitude is about 1° farther south than in 1960.

TABLE III. VARIATION OF HOMOGENEOUS ARCS WITH TIME AND GEOMAGNETIC LATITUDE

Elevation	U.T.	19	20	21	22	23	24	01	02	03	04	05	06	07	08	09	*Totals*	*Geomagnetic Latitude* (degrees)
½								1									1	76
1			2														2	75
2		2			1	2	1			1		1	3				11	74
3					3	6	1	3	5	1		3	6				28	73
4–5					3	9	9	11	5	12	11	8	8	4			80	72
6–7					1	2	5	7	16	11	9	2	3				56	71
8–10					1	4	4	5	18	15	12	11	1	4			75	70
11–15					2		3				3						8	69
16–23							1	1	2	1							5	68
24–40							3	1	2								6	67
41–90						3	4	2									9	66
91–140					4		4				1						9	65
141–157							1										1	64
158–165								1									1	63
≧ 166					1	1	1										3	
Median Latitudes (degrees south)					70·8	72·3	70·6	71·6	71·0	70·9	71·0	71·2	72·6					

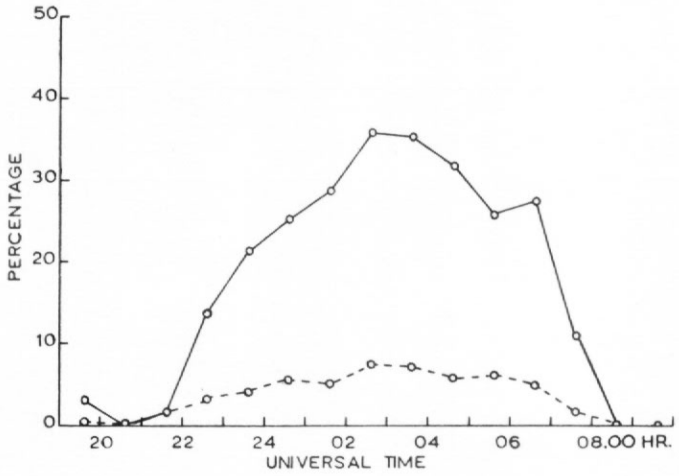

Fig. 10. Diurnal variation of homogeneous arcs.

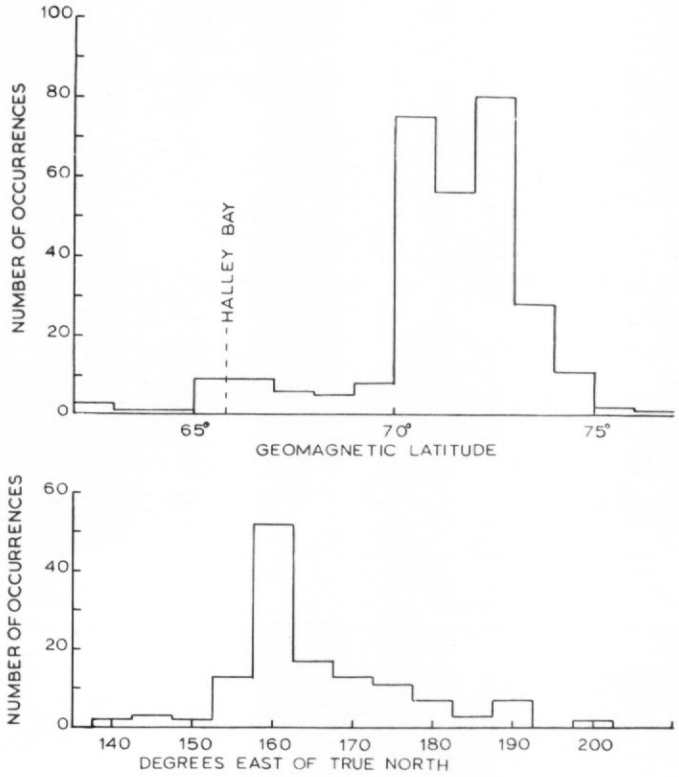

Fig. 11. Geomagnetic latitude and azimuth distributions of homogeneous arcs, 1956–63.

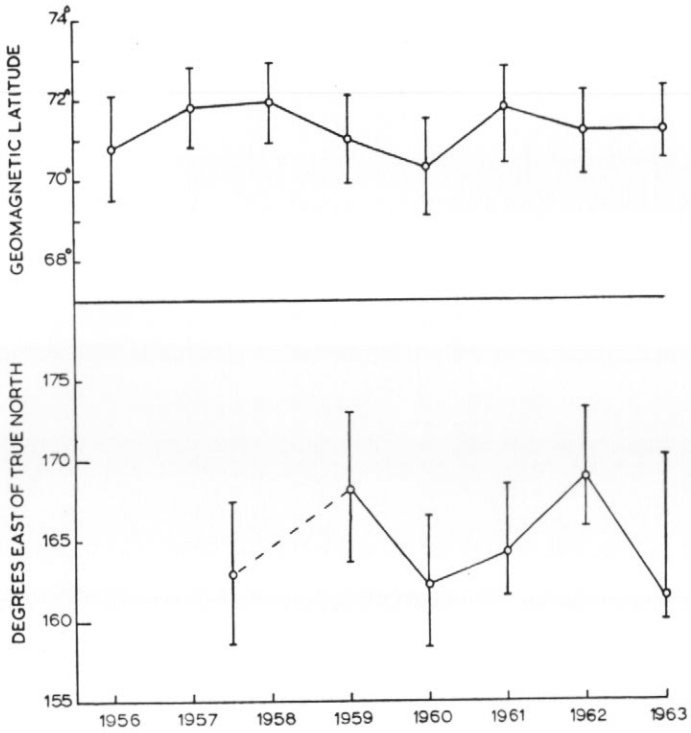

Fig. 12. Median latitudes and median azimuth positions of homogeneous arcs.

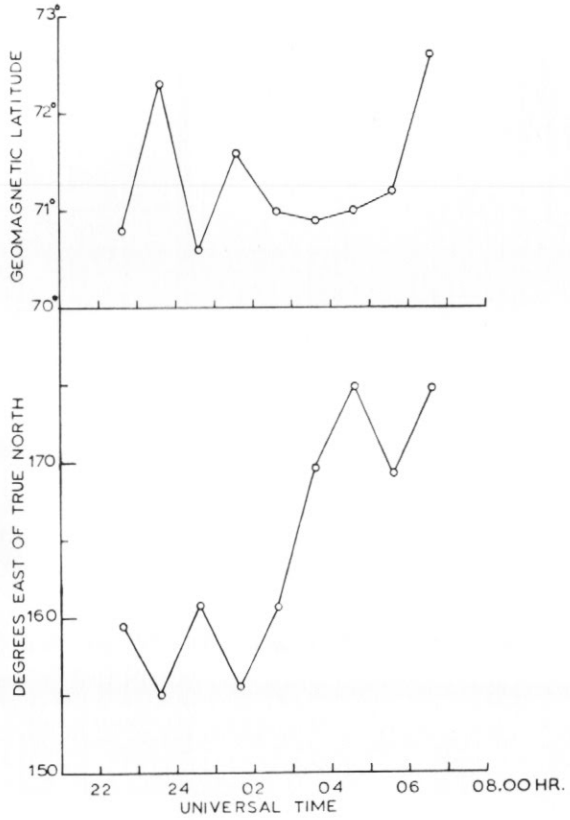

Fig. 13. Diurnal variations of median geomagnetic latitude and mean azimuth of homogeneous arcs.

Fig. 13 gives the diurnal variations of the median latitude and mean azimuth of homogeneous arcs. The latitude variation is very similar to that of previous years, with a rather irregular variation before local midnight, and then a northerly movement until 02.00 local time (approximately 04.00 U.T.), followed by a southerly movement after 02.00 local time. The trends in the mean azimuths are also very much the same with a fairly constant position before local midnight and then a westerly drift after local midnight. In 1963 the position before local midnight was somewhat farther east than it had been in previous years, with subsequently a more violent change of position after local midnight.

Conclusions

As would be expected, the approach of years with less solar activity has resulted in a reduction in the frequency of occurrences of aurorae at Halley Bay. There is, however, a greater reduction in frequency in 1963 than would have been expected from the results of the previous two years' observations. This sudden reduction in frequency is caused by the much smaller number of homogeneous arcs and diffuse surfaces seen in 1963; this reduction in frequency of occurrence of diffuse surfaces is a reversal of the tendency towards a steady increase in frequency of these forms during the years after sunspot maximum in 1957 and 1958.

On the whole the diurnal variations in 1963 suggest that the pattern of auroral activity at Halley Bay was very much the same as it had been during the previous two or three years, except that there were considerably fewer homogeneous arcs and diffuse surfaces than in 1961 and 1962.

Homogeneous arcs appear to exhibit the same changes of position during the night as they did in previous years; they are the main feature of auroral displays at Halley Bay and exhibit a morning break-up into diffuse surfaces, although this seems to occur sometimes a little earlier and perhaps a little less frequently.

Acknowledgements

The author is grateful to M. Walford for his supervision of the auroral observations at Halley Bay during 1963, and to N. Mann, M. M. Samuel, M. J. Winterton and R. Worsfold, all of whom helped with these observations. He would also like to express his thanks to Mr. J. Paton, University of Edinburgh, for his help and encouragement during the writing of this paper.

MS. received 10 August 1964

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