ANALYSIS OF VISUAL AURORAL OBSERVATIONS AT HALLEY BAY, 1964

By W. M. Sievwright

Abstract. A statistical analysis is made of visual auroral observations carried out at the Halley Bay station in 1964. Comparison is made with the results of previous years. The diurnal variations in occurrence of the main types of aurorae are given. The positions of quiet arcs in geomagnetic latitude and azimuth are compared with the positions in the years 1956–63.

In 1964, the position of the Halley Bay station was lat. 75°31′S., long. 26°43′W. in geographic coordinates or lat. 65·8°S., long. 24·2°E. in geomagnetic coordinates (the position of the geomagnetic pole being taken as lat. 78·5°S., long. 111°E.). The direction of the geomagnetic pole is 160·9° east of true north and the magnetic dip pole lies 179° east of true north. Local midnight is 1 hr. 45 min. after midnight U.T. and geomagnetic midnight 3 hr. after midnight U.T.

The observations in 1964 were carried out by the author. Those used in this analysis were made at 15 min. intervals whenever the sun was more than 12° below the horizon (but only from 18.15 to 10.00 U.T. during the darkest months).

The classification of auroral forms used in recording the observations was that given in the *International auroral atlas*. In the analysis, auroral forms have been grouped to correspond more closely to the earlier classification given in the *Photographic atlas of auroral forms*. This has been done to facilitate comparison with the results of previous years.

Analysis of Results

The sun was more than 12° below the horizon on 200 nights in 1964 and auroral observations were made on all of these nights. On 31 of these, the sky was completely obscured for the whole night by cloud or drifting snow. Aurorae were seen on 76 nights and detected on a further 34 nights with the aid of Fabry-Perot interference filters transmitting the 5577 Å line of monatomic oxygen. Aurorae reached the overhead position (within 0·5° of latitude of the station, corresponding to an elevation greater than 60°) on 18 nights. The sky was clear and dark on only ten nights but on all but one of these (observations on that night being made for only a few hours) aurorae were present (cf. 66·7 per cent of clear dark nights in 1963). It should be possible to record any occurrence of overhead aurorae provided that the sky is not completely obscured; overhead aurorae occurred on 10·7 per cent of possible nights (cf. 5·9 per cent in 1963). An increase in activity compared with 1963 is thus indicated but the values are still considerably less than those for 1961 and 1962. It should be noted that in 1963 there was no full-time auroral observer at Halley Bay. The subjective error introduced into the results for 1963 as a result of the sharing of observations by five people may have been more serious than thought by Blundell (1965).

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 interval refer to those taken at quarter past, half past, quarter to, and on the hour (i.e. the interval 23.00–00.00 U.T. refers to observations made at 23.15, 23.30, 23.45 and 00.00 U.T.). Table II is similar but it lists all observations made while the sun was more than 12° below the horizon.

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

a. Number of observations.
b. Number of observations with aurorae present.
c. Number of observations with active forms present.
d. Number of observations when aurorae were overhead.
e. Number of observations with diffuse surfaces present.
f. Number of observations with glows present.
g. Number of observations with quiet homogeneous arcs present.

Rows *b′* . . . . . *g′* give the respective percentage frequencies using the figures in row *a* of each table. The last column in each table gives the total number of observations made

TABLE I. DIURNAL VARIATIONS
(Clear dark periods)

U.T.	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	*Totals*
a	46	56	64	65	64	77	86	99	96	96	90	78	69	56	50	39	9		1,140
b		13	28	25	36	53	71	80	80	77	71	59	44	32	26	17	6		718
c					1	5	1	2	7	10	8	5	7	7	13	8	4		78
d						1		1	2	4	4	4	5	4	5	7	4		41
e		8	11	2	5	10	11	14	9	12	25	9	14	8	14	11	5		168
f		1	4	4	3	4	5	7	7	4			7	7	2				55
g		2	5	13	17	21	31	26	42	34	27	23	3	5	2		1		252
																			(per cent)
b′		23·2	43·8	38·5	56·3	68·8	82·6	80·8	83·3	80·3	78·9	75·6	63·8	57·1	52·0	43·6	66·7		63·0
c′					1·5	6·5	1·2	2·0	7·3	10·4	8·9	6·4	10·1	12·5	26·0	20·5	44·4		6·8
d′						1·3		1·0	2·1	4·2	4·4	5·1	7·2	7·1	10·0	17·9	44·4		3·6
e′		14·3	17·2	3·1	7·8	13·0	12·8	14·1	9·4	12·5	27·8	11·5	20·3	14·3	28·0	28·2	55·6		14·7
f′		1·8	6·3	6·2	4·7	5·2	5·8	7·1	7·3	4·2			10·1	12·5	4·0				4·8
g′		3·6	7·8	28·5	26·6	27·3	36·0	26·3	43·8	35·4	30·0	29·5	4·4	8·9	4·0		11·1		22·1

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

U.T.	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	*Totals*
a	347	480	571	650	710	757	784	800	796	764	729	672	602	513	416	315	11		9,917
b		28	43	57	89	124	161	190	211	195	173	141	103	66	44	27	7		1,659
c		2		3	5	8	6	12	13	17	12	11	10	7	13	9	4		132
d				4	5	1		8	12	20	11	7	9	4	4	6	4		95
e		14	12	6	9	12	21	17	12	20	27	15	17	9	16	9			216
f		2	5	13	10	6	10	18	21	21	14	9	16	14	8				167
g		3	6	16	22	32	39	32	53	43	41	35	6	5	2		1		336
																			(per cent)
b′		5·8	7·5	8·8	12·5	16·3	20·5	23·8	26·5	25·5	23·7	21·0	17·1	12·9	10·6	8·6	63·6		16·7
c′		0·4		0·5	0·7	1·1	0·8	1·5	1·6	2·2	1·6	1·6	1·7	1·4	3·1	2·9	36·4		1·3
d′				0·6	0·7	0·1		1·0	1·5	2·6	1·5	1·0	1·4	0·8	1·0	1·9	36·4		1·0
e′		2·9	2·1	0·9	1·3	1·6	2·7	2·1	1·5	2·6	3·7	2·2	2·8	1·8	3·8	2·9			2·2
f′		0·4	0·9	2·0	1·4	0·9	1·3	2·3	2·6	2·7	1·9	1·3	2·7	2·7	1·9				1·7
g′		0·6	1·1	2·4	3·1	4·2	5·0	4·0	6·7	5·6	5·6	5·2	1·0	1·0	0·5		9·1		3·4

throughout the year with the various forms present and the respective percentage frequencies.

In the above groupings, the active forms in row *c* include all the types of activity and pulsing which were observed during the year, i.e. conditions a_1, a_2, a_3 and a_4, and p_2 and p_3; also activity not well described by any of the above conditions, denoted in the records by *a*, and a type of pulsing denoted by p_5 (this will be described in a later paper by the author). In row *d*, any aurorae reaching an elevation of 60° are included. In row *e*, diffuse surfaces are taken to be forms recorded as *P*, *N* or *V* with lower border above the horizon. In row *f*, glows include all forms recorded as *N* or *V* with lower border below the horizon.

In Fig. 1, the percentage frequency of all aurorae and overhead aurorae during clear dark periods (last column of rows *b'* and *d'* in Table I) is compared with the values for the years

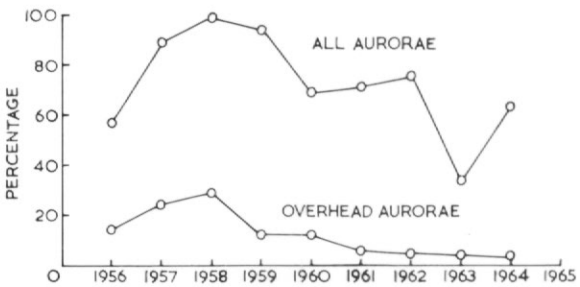

Fig. 1. Occurrence of all aurorae and overhead aurorae, 1956–64.

1956 to 1963. Although the percentage frequency of occurrence of overhead aurorae is close to the values for the past few years, that of all aurorae shows a considerable increase over the 1963 value. The value of 63 per cent is only 10 per cent less than the level for the years 1961 and 1962. Overhead aurorae are unlikely to be missed by any observer but it is possible that some low faint aurorae were missed by the observers in 1963.

Quiet arcs, active forms and diffuse surfaces are similarly compared in Fig. 2. It can be seen that in the case of quiet arcs there was little change from the 1963 value, these two years having less than any year since the Halley Bay station was established.

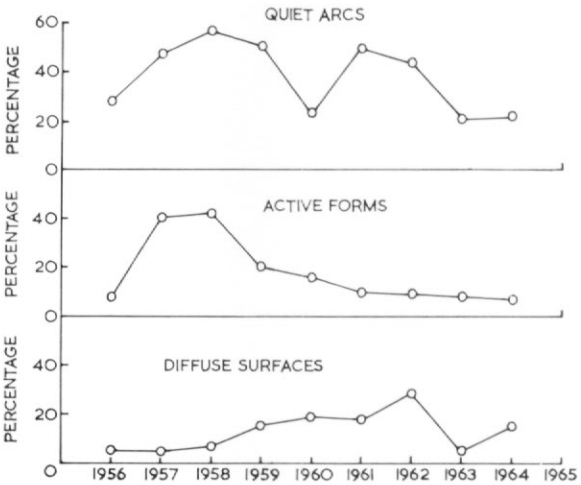

Fig. 2. Occurrence of various auroral forms, 1956–64. Values for active forms and diffuse surfaces in 1959 are for all clear periods, including moonlit periods.

The incidence of active forms has decreased slowly since 1959, following the rapid drop from the level of 1958. If the value for 1956 is representative for that epoch in the solar cycle, it can be expected that there will be little change in the percentage frequency of active forms for 1965 and 1966.

In the case of diffuse surfaces, it appears that, although the amount present was considerably less than that in the peak year of 1962, there has been an increase since 1963. However, since diffuse surfaces are normally faint, the effect of observer error may again be important.

The frequency with which flaming occurred has altered little since 1961, if clear dark periods are considered (Fig. 3), but the rapid drop in the years from 1960 to 1963, when all times with

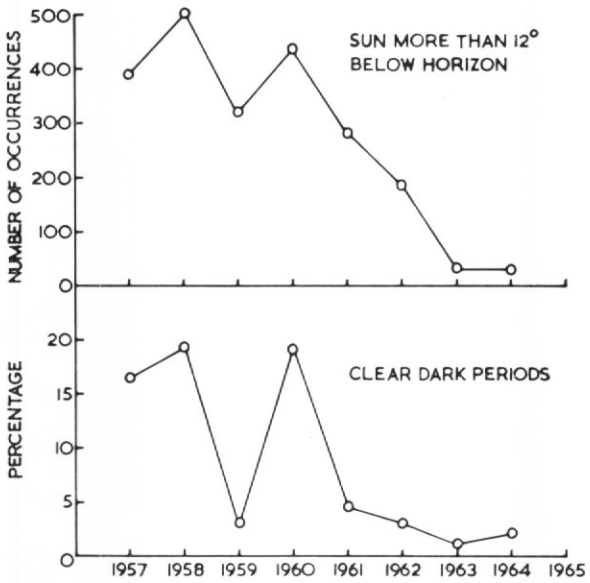

Fig. 3. Occurrence of flaming, 1957–64.

the sun more than 12° below the horizon are included, now seems to have ceased. The phenomenon was seen during 28 observations in 1964, 23 of these (2·02 per cent) being when the sky was clear and dark.

Red type A was never recorded in 1964. Unfortunately, due to the author's defective colour vision, it is impossible to state that red type A never occurred.

All values for previous years have been taken from Blundell (1965).

The diurnal variations of the various forms have been plotted in Figs. 4 to 9, using the values in rows *b′* . . . . . *g′* in Tables I and II. Solid lines show values taken from Table I while dotted lines show those from Table II.

In Fig. 4 the diurnal variation of all aurorae is plotted. The maximum of the curves is around 02.30 U.T. This is earlier than in previous years, a fact emphasized if clear dark periods only are considered. In that case, the maximum is flat, values from 00.00–01.00 to 03.00–04.00 U.T. showing little variation. In contrast to the situation in 1963, aurorae were present on a number of occasions after 08.00 U.T., the fall-off in values after the maximum being slower than the rise up to the value for 00.00–01.00 U.T.

The diurnal variation of active forms is shown in Fig. 5. Active aurorae were a morning feature in 1964. This is in marked contrast to previous years when a maximum around local midnight was found.

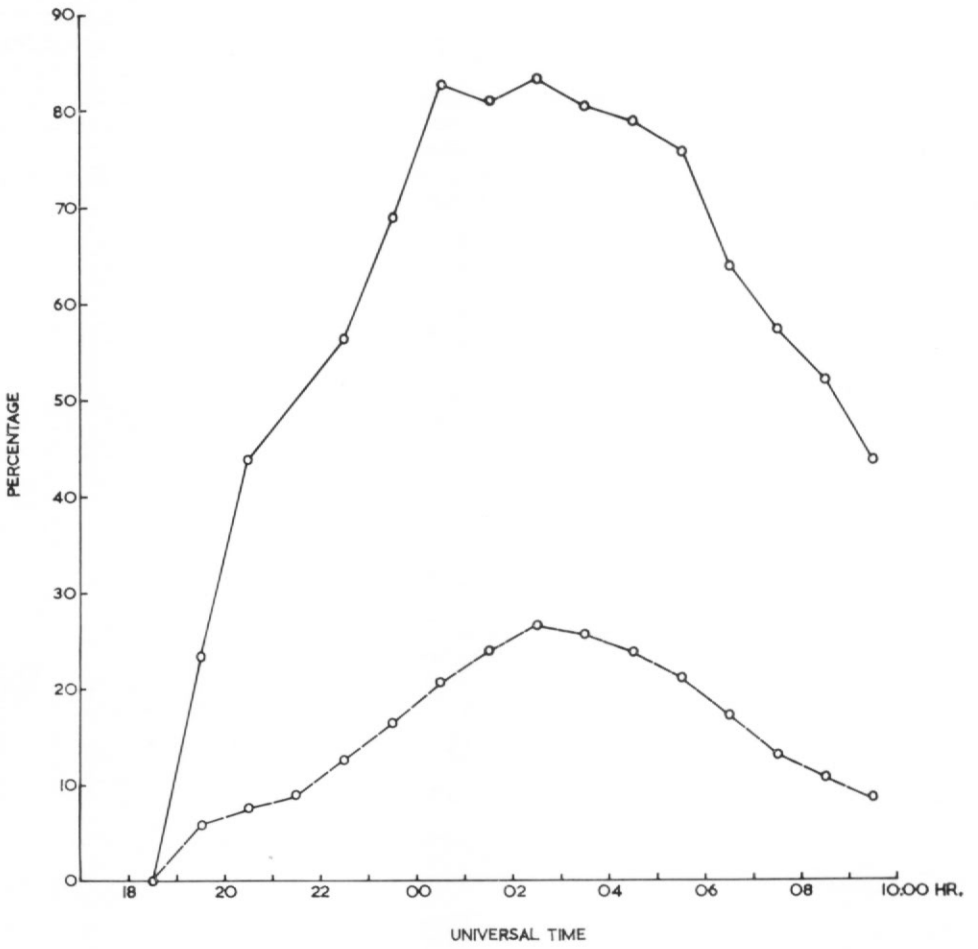

Fig. 4. Diurnal variation of all aurorae.

Since almost all aurorae which reached an elevation greater than 60° were active, it is not surprising that the curve of Fig. 6, showing the diurnal variation in occurrence of overhead aurorae, is very similar to that of Fig. 5. The similarity between the curves of occurrence of overhead aurorae and active aurorae (Figs. 1 and 2) in the years 1956–64 implies that the above is generally true of aurorae seen from Halley Bay.

From Fig. 7 it can be seen that diffuse surfaces occurred throughout the night with only a slight bias towards morning hours. It is possible that the higher frequency in the evening hours is due to the inclusion of forms that would not have been classified as diffuse surfaces by previous workers.

As in 1961 and 1962, glows occurred both in the evening and in the morning (Fig. 8) but the shape of the curves varies greatly from year to year; this may well be due to the small samples involved in each year. (Data for 1961 and 1962 are taken from Blundell (1966).)

Fig. 9 shows the diurnal variation of quiet arcs. When clear dark periods are considered, it is seen that compared with recent years the curve has shifted towards the evening hours. The change is most evident in the rapid rise in frequency of occurrence at hour 21.00–22.00 U.T. Also by 06.00–07.00 U.T. the frequency had dropped to a very low level again in contrast

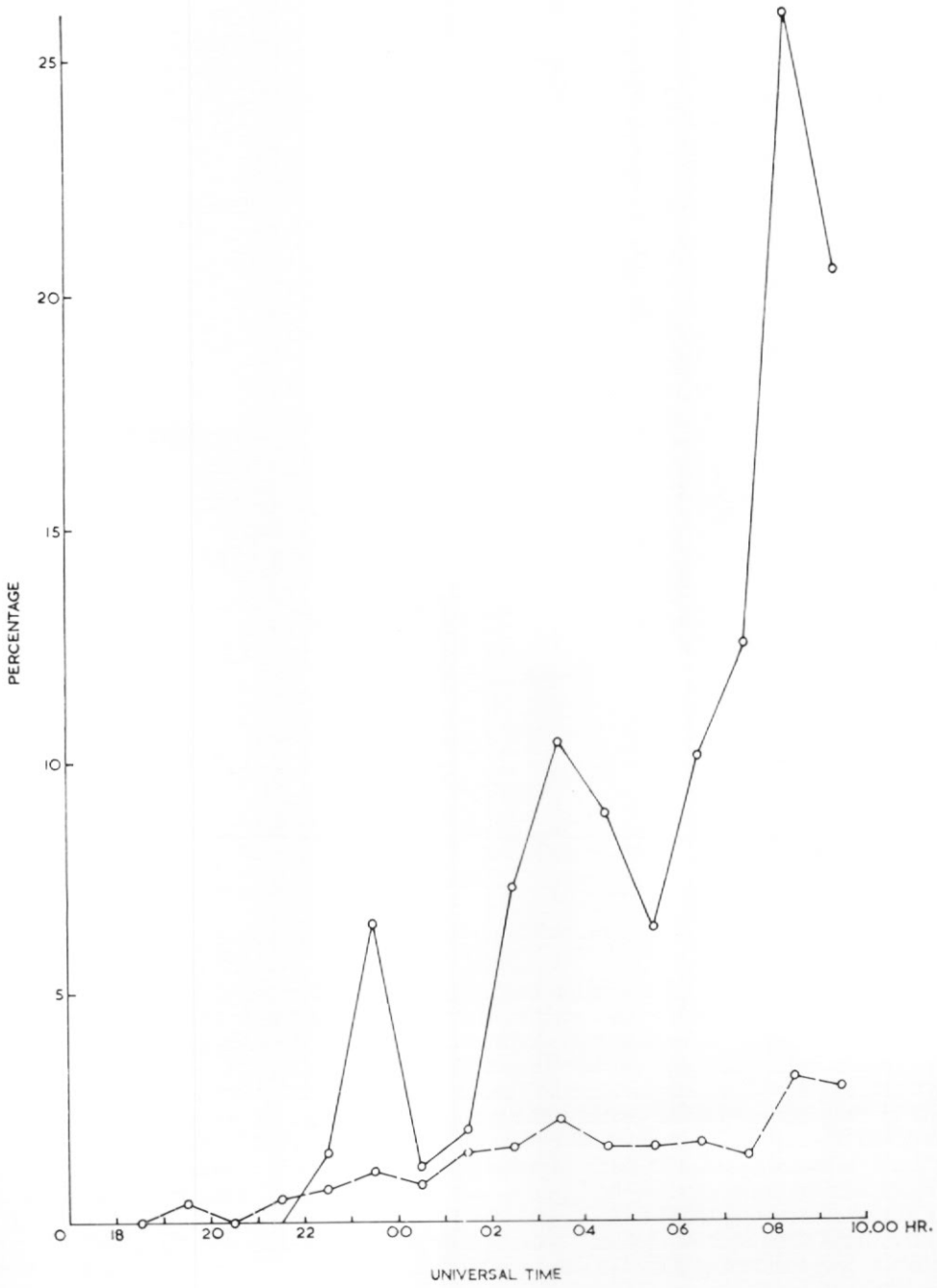

Fig. 5. Diurnal variation of active aurorae.

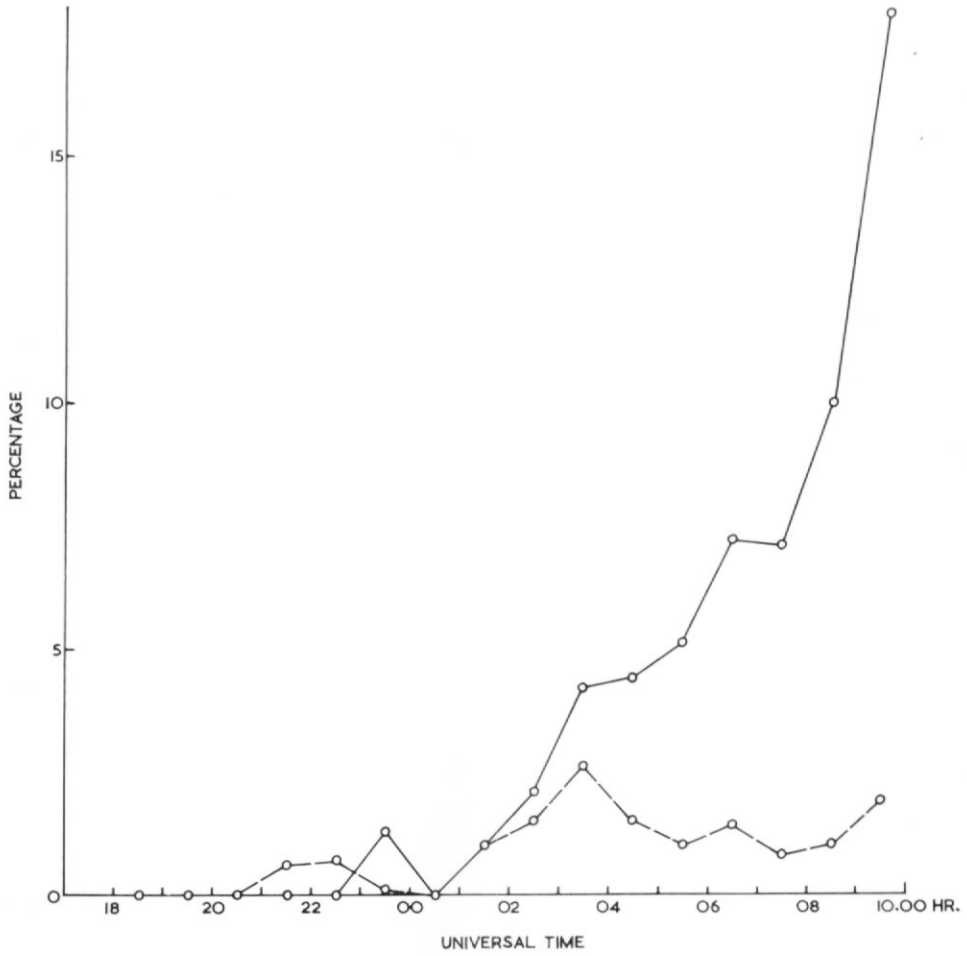

Fig. 6. Diurnal variation of overhead aurorae.

to the slower and later decrease in the morning hours in other years. When all periods with the sun more than 12° below the horizon are considered the shift to evening hours is less marked. A maximum in frequency of occurrence of arcs in the evening hours was a feature of the results in the International Geophysical Year.

When the distributions of quiet arcs in "geomagnetic latitude" (calculated assuming that the centre of each arc lies on the geomagnetic meridian at a height of 100 km.) and azimuth are considered (Fig. 10), it is found that the zone within which most arcs occur has altered position very little in recent years. The distribution in time and "latitude" is tabulated in Table III. In azimuth, arcs are more often to be found west of the geomagnetic meridian than in 1963, the distribution resembling that of 1962.

The diurnal variations of median "geomagnetic latitude" and mean azimuth of the centres of quiet arcs are shown in Fig. 11. The variation in median latitude is similar to that of other years but the lowest latitude, 71°, is reached earlier in the night. The mean azimuth changes from around 160° east of true north early in the night to around 180° in late morning. The variation is similar to that of previous years but it takes place more slowly than in 1963. The curve is again similar to that for 1962.

The median geomagnetic latitude for the year was 71·4°S., with interquartile values of 72·0° and 70·3°. The median azimuth was 166·5° east of true north with interquartile values of 172·0° and 162·5°. These values are plotted along with the corresponding values for the

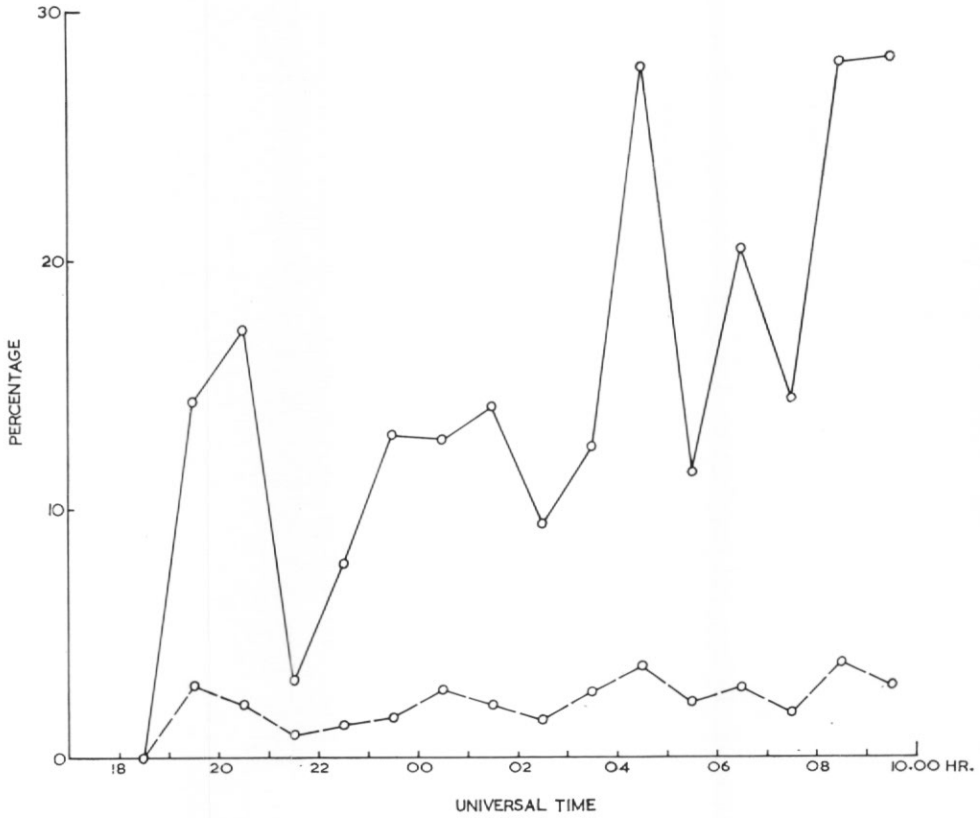

Fig. 7. Diurnal variation of diffuse surfaces.

years 1956–63 in Fig. 12. There has been little change in median latitude since 1961, and the range of variation since observations began in 1956 is small. The variation in median azimuth is irregular.

Conclusions

As was to be expected in the International Quiet Sun Year, aurorae occurred at the Halley Bay station less frequently than in most of the years during which observations have been made. Overhead and active aurorae were rarer than in any year so far. The very low level of occurrence of all aurorae reported in 1963 was not maintained and it is suggested that observer error may have been more important than considered earlier.

Active aurorae have become a morning feature, while the curve of diurnal variation of quiet arcs has shifted a little towards the evening hours. Both diffuse surfaces and glows appear to have become a more general feature of aurorae seen from Halley Bay.

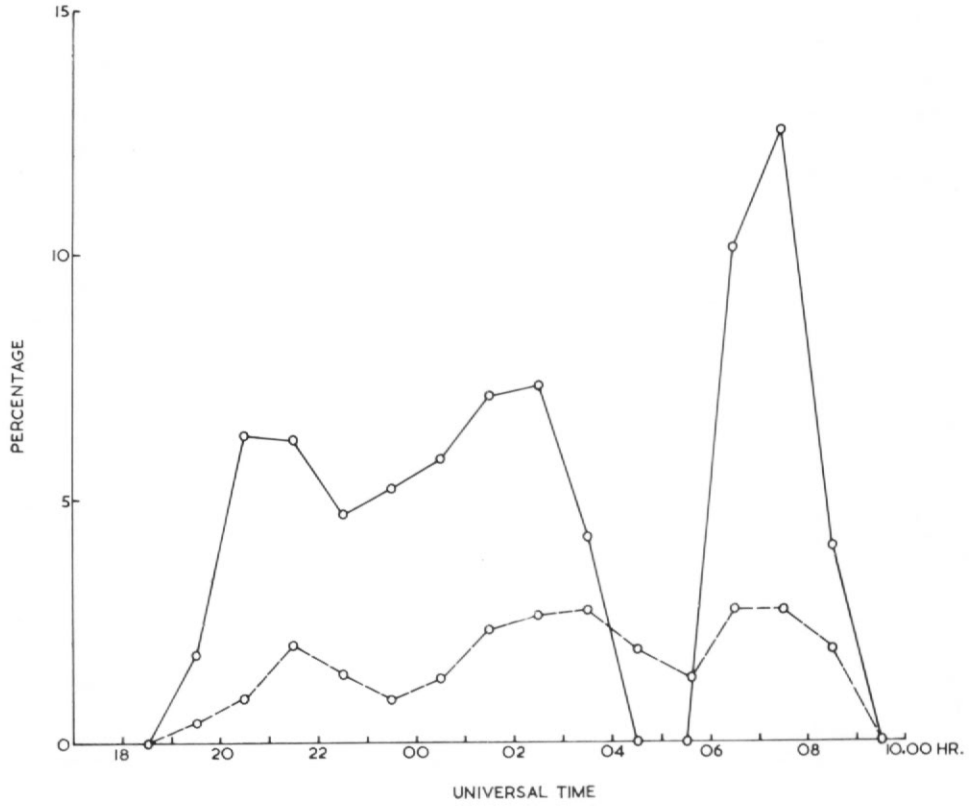

Fig. 8. Diurnal variation of glows.

The positions of occurrence of homogeneous arcs were little different from those of previous years and there is no evidence to suggest a shift in the position of the quiet arc zone.

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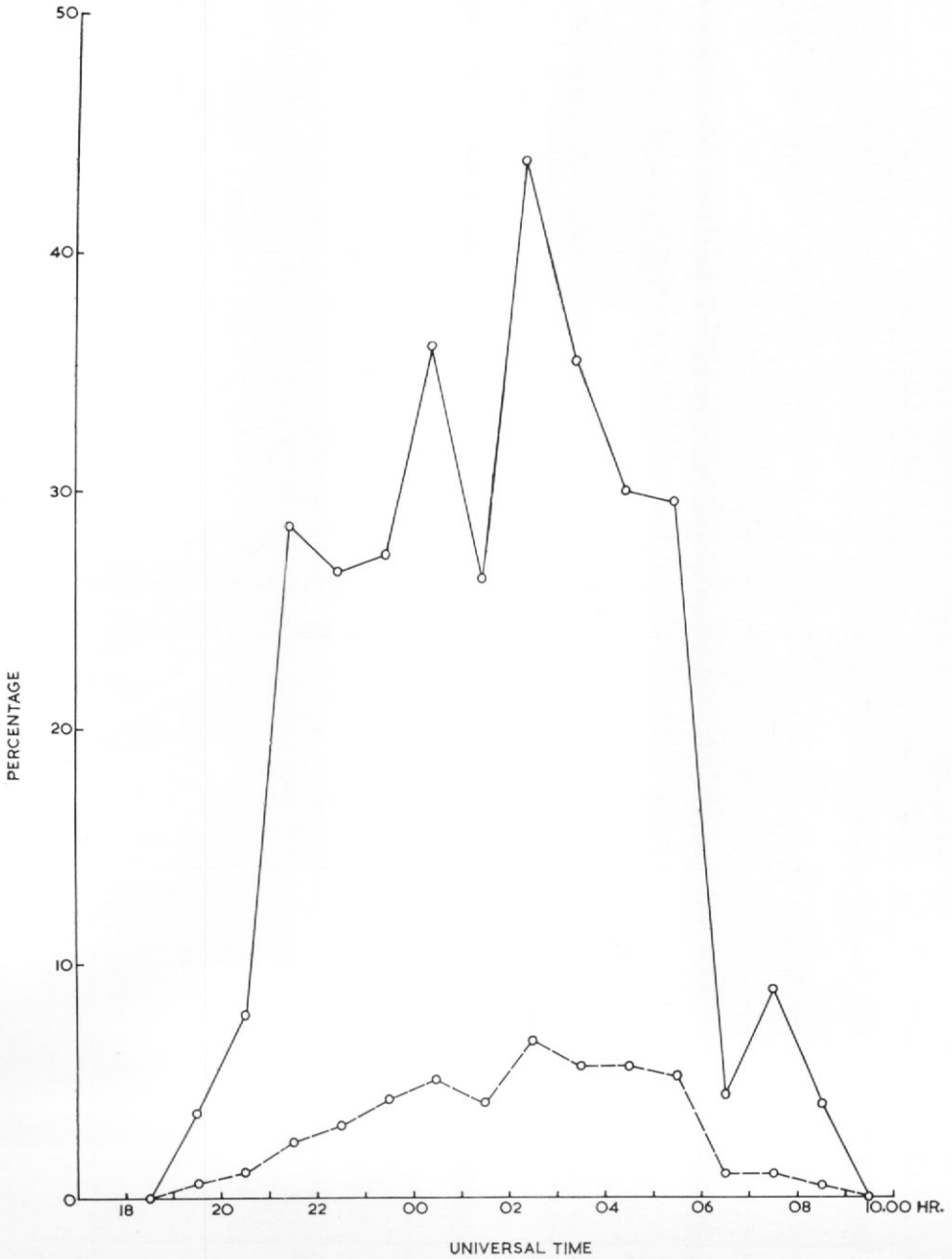

Fig. 9. Diurnal variation of homogeneous arcs, 1964.

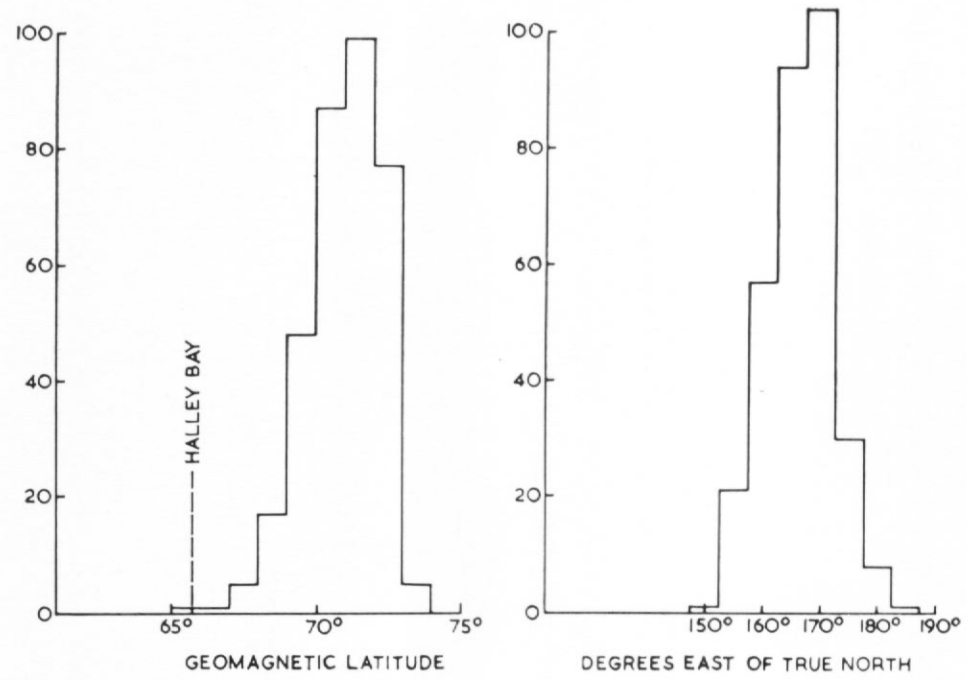

Fig. 10. Distribution of quiet arcs in geomagnetic latitude and azimuth.

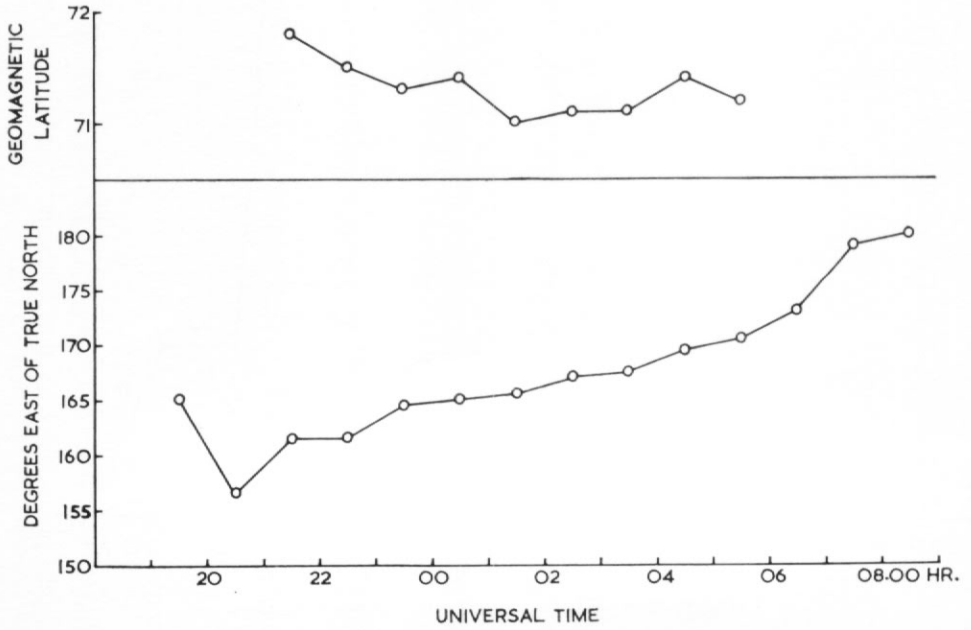

Fig. 11. Diurnal variations of median geomagnetic latitude and mean azimuth of homogeneous arcs.

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

Elevation (degrees)	U.T.	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	*Totals*	*Geomagnetic latitude* (degrees south)
1																					74
2																					73
3					1				1	1					1	1				5	72
4–5				1	4	6	6	7	10	1	11	7	17	6		1				77	71
6–7					1	7	10	13	14	8	13	9	7	11	3	3				99	70
8–10				2		1	4	6	9	13	14	15	12	10	1					87	69
11–15					1	1	4	10	10	4	6	3	5	4						48	68
16–23									5	2	3	2	3	1			1			17	67
24–40										2	2			1						5	66
41–90														1						1	65
91–140																			1	1	
141–157																					
Median latitudes					71·8	71·5	71·3	71·4	71·0	71·1	71·1	71·4	71·2								

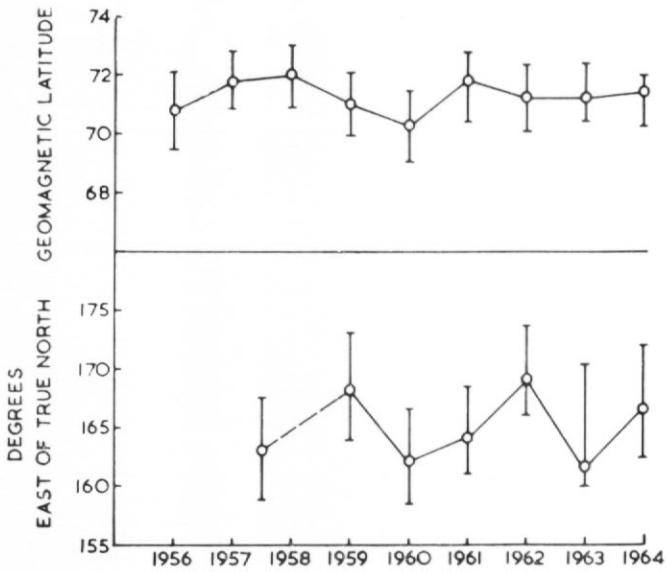

Fig. 12. Median latitudes and median azimuth positions of homogeneous arcs.

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