ANALYSIS OF VISUAL AURORAL OBSERVATIONS AT HALLEY BAY, 1966

By M. J. SHAW

ABSTRACT. A statistical analysis is made of visual auroral observations carried out at the Halley Bay station in 1966, and the results are compared with those 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 derived.

THE mean geographic coordinates of Halley Bay station in 1966 were lat. 75°31′S., long. 26°45′W. The corresponding geomagnetic dipole coordinates are −65·7, 24·2, with the geomagnetic meridian 161° east of true north; the local magnetic meridian is 179° east of true north. Mean local midnight is 01.45 U.T. and mean geomagnetic midnight is 03.00 U.T.

OBSERVATIONS

Visual auroral observations were made at the quarter hours U.T. throughout each night of the period 21 March to 23 September, with the exception of the week 23–29 April, when the observer was incapacitated following an accident. In this context, "night" refers to the interval 19.15–10.00 U.T. or that shorter interval during which the sun was more than 12° below the horizon. All auroral forms observed were recorded according to the classification set out in the *International auroral atlas*. An open-sight alidade was used to measure elevations (to the nearest degree) and a horizontal circle to measure azimuths (to the nearest 5°).

The ice shelf around the station is flat and, since all the major buildings are below the snow surface, the complete hemisphere of the sky is visible to the observer. Unfortunately, the sky is often obscured by cloud; out of 179 nights of observation only ten were completely clear and dark. The mean cloud cover during the period covered by the observations was just under 5 oktas.

ANALYSIS OF RESULTS

Diurnal variations

The observations have been summed over hourly intervals, ending on the hour (thus, the interval 22.00–23.00 U.T. refers to observations made at 22.15, 22.30, 22.45 and 23.00 U.T.). As most of the aurorae seen from the station appear low in the southern sky, the observing conditions are important in assessing the frequency of occurrence. Table I gives the results obtained during clear dark periods; that is, with a clear sky and with the moon less than half-full. Table II gives the results from all observations.

The individual rows represent the following:

a. Number of observations.

b. Number of observations with aurorae present.

c. Number of observations with active or pulsing aurorae present (conditions a_1, a_2, a_3, a_4, p_1, p_2, p_3).

d. Number of observations when aurorae were overhead (i.e. aurorae with elevation greater than 60°).

e. Number of observations with the diffuse forms *patch* (*P*) or *veil* (*V*) present.

f. Number of observations with quiet homogeneous arcs present.

Rows *b′* .... *f′* give the frequencies of occurrence of the respective auroral forms as percentages of the total number of observations, row *a*, made during the same hourly interval. These percentage frequencies have been plotted in Figs. 1 to 5; solid lines show values taken from Table I, while broken lines show those from Table II.

TABLE I. DIURNAL VARIATIONS
(Clear dark periods)

U.T.	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	*Totals*
a	19	30	45	56	70	78	80	92	95	82	67	50	47	42	24		877
b	2	12	15	21	34	49	68	86	84	70	53	26	13	8	4		545
c			2	4	16	15	18	13	20	21	9	4	4	3			129
d					3	5	4	0	2	4	4	2					24
e					1	6	7	6	10	12	7	4	4	1	3		61
f			5	5	9	17	28	33	30	20	18	13	6	1	2		187
																	(per cent)
b′	10·5	40·0	33·3	37·5	48·6	62·8	85·0	93·5	88·4	85·4	79·1	52·0	27·7	19·0	16·7		62·1
c′			4·4	7·1	22·9	19·2	22·5	14·1	21·1	25·6	13·4	8·0	8·5	7·1			14·7
d′					4·3	6·4	5·0	0	2·1	4·9	6·0	4·0					2·7
e′					1·4	7·7	8·7	6·5	10·5	14·6	10·4	8·0	8·5	2·4	12·5		7·0
f′			11·1	8·9	12·9	21·8	35·0	35·9	31·6	24·4	26·9	26·0	12·8	2·4	8·3		21·3

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

U.T.	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	*Totals*
a	310	473	589	655	706	716	716	716	716	684	625	585	517	433	316		8,757
b	16	49	64	90	122	142	168	189	181	179	139	106	60	48	22		1,575
c	4	5	10	12	29	28	31	26	38	39	26	14	17	7	3		289
d	4	4	5	5	12	9	11	10	10	18	10	9	7	2	3		119
e				1	6	13	16	10	21	29	18	12	12	3	6		147
f		2	9	14	14	20	33	45	45	38	30	22	10	1	4		287
																	(per cent)
b′	5·2	10·4	10·9	13·7	17·3	19·8	23·5	26·4	25·3	26·2	22·2	18·1	11·6	11·1	7·0		18·0
c′	1·3	1·1	1·7	1·8	4·1	3·9	4·3	3·6	5·3	5·7	4·2	2·4	3·3	1·6	0·9		3·3
d′	1·3	0·8	0·8	0·8	1·7	1·3	1·5	1·4	1·4	2·6	1·6	1·5	1·4	0·5	0·9		1·4
e′				0·2	0·8	1·8	2·2	1·4	2·9	4·2	2·9	2·1	2·3	0·7	1·9		1·7
f′		0·4	1·5	2·1	2·0	2·8	4·6	6·3	6·3	5·6	4·8	3·8	1·9	0·2	1·3		3·3

Fig. 1 shows the diurnal variations in the frequency of occurrence of all aurorae. Between 01.00 and 06.00 U.T., the percentage frequencies of occurrence in clear dark conditions were somewhat higher than those recorded during the years of minimum solar activity; the maximum frequency recorded in 1964 was 83·3 per cent and in 1965 it was 90·2 per cent (Sievwright, 1967*a*, *b*). The frequencies outside these hours were less than those recorded in 1964 and 1965, and the overall frequency of occurrence was slightly lower than in those years; 62·1 per cent for 1966, while the corresponding overall frequencies for 1964 and 1965 were 63·0 and 67·3 per cent, respectively. Clear dark periods form such a small sample in any one year (on average, about 24 nights) that differences of this magnitude are probably quite insignificant.

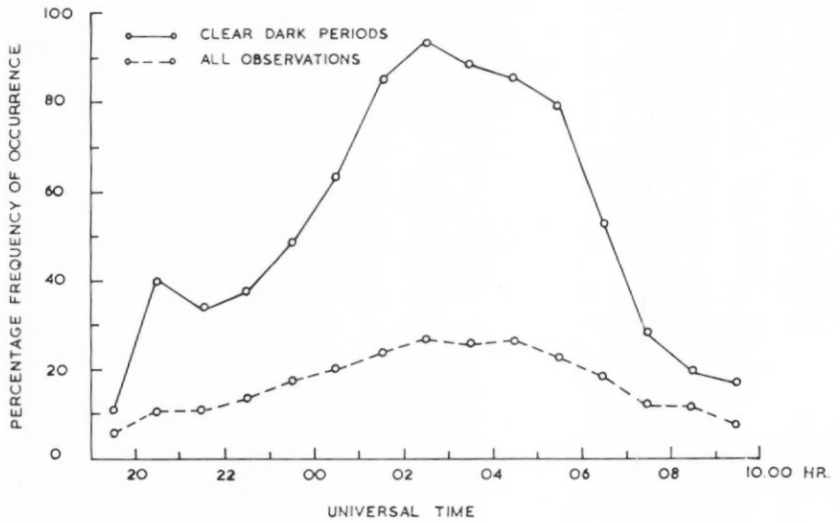

Fig. 1. Diurnal variation of occurrence frequency of all aurorae, 1966.

The diurnal variation of active aurorae shown in Fig. 2 differs markedly from the results obtained in 1964 and 1965. In those years, active aurorae were much less frequent and they occurred more often in the morning than in the evening hours. In 1966, however, there were several large displays starting well before midnight, usually associated with magnetic storms.

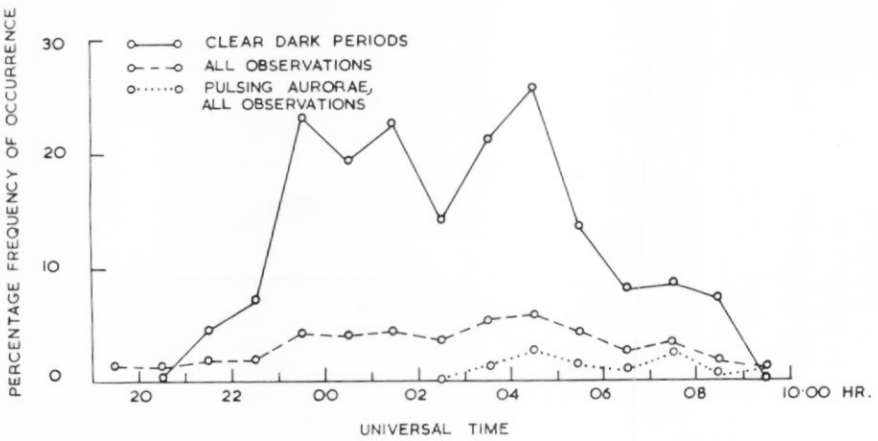

Fig. 2. Diurnal variation of occurrence frequency of active aurorae, 1966.

The solid and broken curves show the combined frequencies of active and pulsing conditions. Pulsing aurorae (p_1, p_2, p_3) occurred in the morning hours only, as shown (for all observations) by the dotted curve.

Overhead aurorae were preponderantly active. The diurnal variation shown in Fig. 3 differs from those observed during sunspot minimum in much the same way as described above for active aurorae.

The diurnal variations of diffuse forms (Fig. 4) and quiet homogeneous arcs (Fig. 5) are quite similar to those observed in 1964 and 1965.

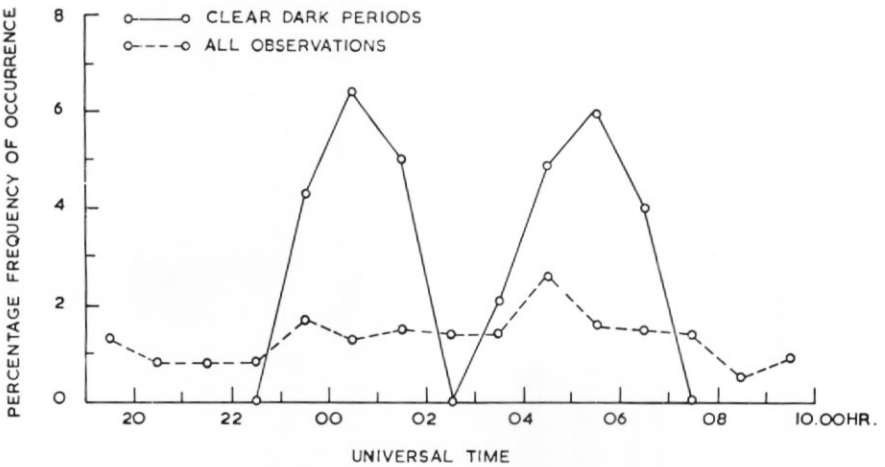

Fig. 3. Diurnal variation of occurrence frequency of overhead aurorae, 1966.

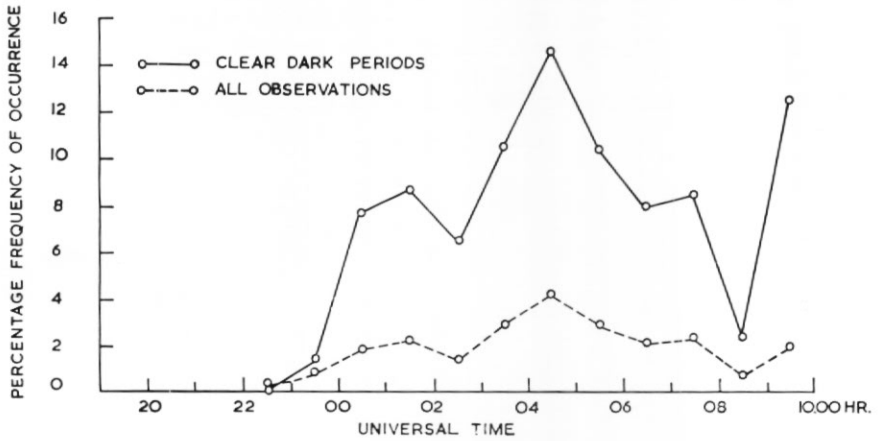

Fig. 4. Diurnal variation of occurrence frequency of diffuse auroral forms, 1966.

Position of quiet homogeneous arcs

The quiet homogeneous arc is the auroral form easiest to locate, because of its simple shape and comparative stability. It is generally agreed that the height of the lower border may be assumed to be 100 km., only small deviations from this value having been found in an extensive series of measurements (Störmer, 1955). It is then possible to locate a quiet arc by measuring elevation and azimuth of the highest point on the lower border, as seen from a single station. Moreover, when the azimuth is not very different from that of the geomagnetic meridian, the distance from the station to the point on the Earth's surface at which the arc is overhead may be taken, without appreciable error, for the difference in geomagnetic latitude of those places. This condition is fulfilled for arcs seen from Halley Bay.

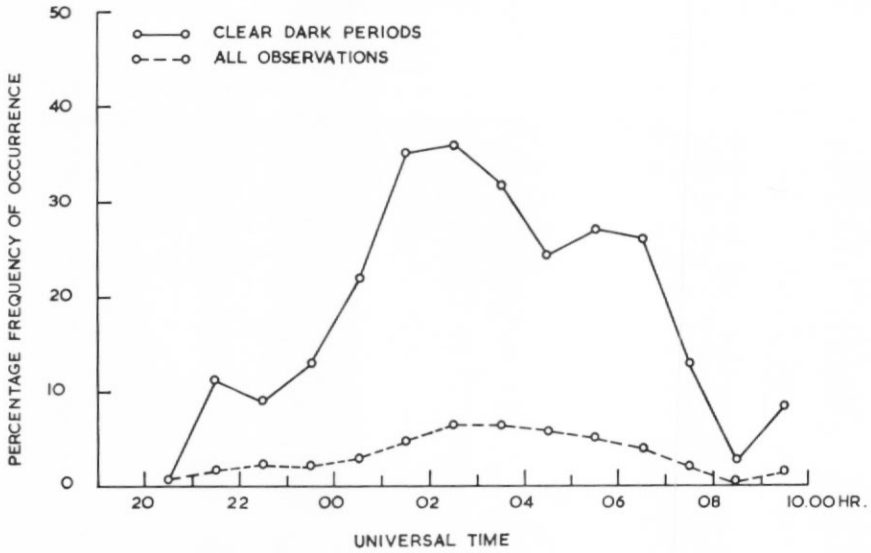

Fig. 5. Diurnal variation of occurrence frequency of quiet homogeneous arcs, 1966.

Table III gives the distribution in elevation for each hour U.T. of the quiet homogeneous arcs seen from Halley Bay in 1966. As noted above, the geomagnetic latitude of an arc is effectively a function of elevation alone, and the elevations have been grouped so as to correspond to 1° steps in latitude, as shown in the extreme right-hand column. Table IV gives the corresponding distribution in azimuth.

As noted by Evans and Thomas (1959), arcs are confined to a narrow belt of geomagnetic latitude, which they called "the quiet arc zone". More precisely, they proposed this term to denote the interquartile range of the distribution of the arcs in latitude. The distributions in geomagnetic latitude and azimuth for 1966 are shown in Fig. 6. The median values were 72·3°S.

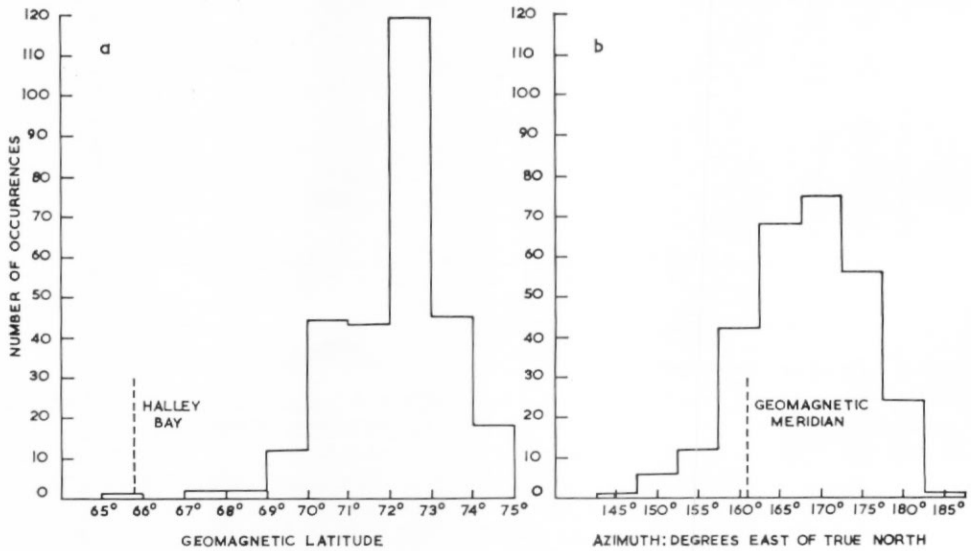

Fig. 6. Number of occurrences of quiet homogeneous arcs in 1966.
a. In each degree of geomagnetic latitude.
b. In 5° intervals of azimuth.

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

Elevation (degrees)	U.T.	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	*Totals*	*Geomagnetic latitude* (degrees south)
1																		75
2				2	2		1	3	1	2		2	2	1		2	18	74
3				2	2	1	1	1	5	9	6	9	7	1	1		45	73
4–5			1	2	5	6	5	13	17	16	20	17	11	4		2	119	72
6–7				2	4	1	5	10	8	4	2	2	1	4			43	71
8–10					1	6	5	5	8	10	8		1				44	70
11–15			1	1			1	1	4	3	1						12	69
16–23							1			1							2	68
24–40									2								2	67
41–90																		66
91–140							1										1	65
Median latitudes				72·7	72·4	72·0	71·4	72·1	72·0	72·3	72·4	72·8	72·3					

TABLE IV. VARIATION OF THE AZIMUTH OF HOMOGENEOUS ARCS IN TIME

Bearing (degrees east of true north)	U.T.	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	*Totals*
145			1														1
150			1	4	1												6
155				2	3	3	4										12
160				1	5	5	1	13	7	2	6	2					42
165				1	5	5	12	9	12	12	10		1	1			68
170						1	1	9	14	14	18	10	4			4	75
175							2	2	12	17	3	12	8				56
180											1	5	8	9	1		24
185													1				1
Mean azimuth		154·4	160·0	161·4	164·0	165·0	168·4	170·1	167·8	173·1	175·9	178·5					

and 165·9° east of north, with interquartile values of 71·3° and 72·9°, and 160·7° and 175·9°, respectively. The quiet arc zone has not been found so far south from Halley Bay before. Nevertheless, the overall range of the median values to date is just 2° of latitude, which is little more than the breadth of the zone. Sheret and Thomas (1961) suggested that there might be a systematic movement of the quiet arc zone during a solar cycle. The annual median values for 1956 to 1965, as presented by Sievwright (1967*b*), together with the values for 1966 show that any such effect must be small. In order to resolve this question, it would appear to be necessary to examine closely the routines adopted by individual observers, and to consider the effects of variations in the observing conditions from year to year.

The existence of a systematic movement of quiet arcs during each night has been commented on by various authors, e.g. Evans and Thomas (1959) and Blundell (1966). This movement is clearly seen in Fig. 7, which shows the median location, for each hour U.T., of the arcs seen in 1966. As noted by the authors cited above, arcs move equatorwards in the evening hours and return polewards in the morning hours, while the azimuth of the centre, or closest point, of the arcs increases continuously throughout the night. It should be remembered that Tables III and IV are based on quarter-hourly observations; thus the actual number of individual arcs referred to in any one hour is very small. It is unlikely that minor details of the curves are significant.

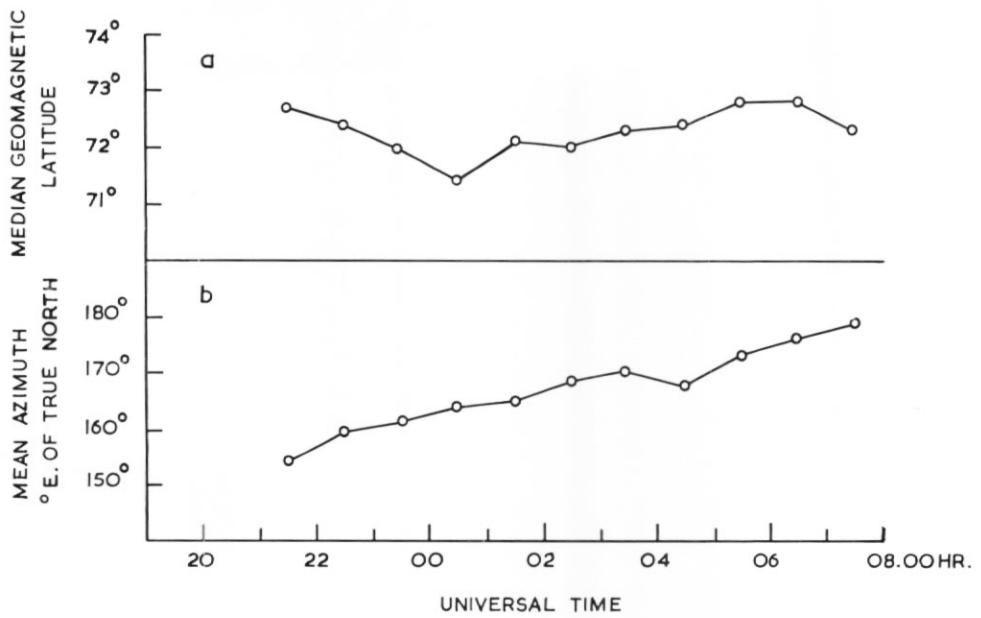

Fig. 7. Median locations of quiet homogeneous arcs for each hour U.T.
a. Geomagnetic latitude.
b. Azimuth.

Conclusions

The overall frequency of occurrence of aurorae in 1966 was quite similar to that recorded in 1964 and 1965. The hourly frequencies in clear dark periods around geomagnetic midnight were higher than in those years but not markedly so. The slight increase in sunspot numbers in 1966 was reflected rather in the changed incidence of active aurorae.

Some large-scale auroral displays, associated with magnetic storms, were seen. Overhead and active aurorae occurred more widely throughout the night than during sunspot minimum,

when these auroral types occurred mostly in the morning hours. Pulsing was observed in the late stages of most big displays but never before geomagnetic midnight.

The quiet arc zone was found to be slightly nearer the geomagnetic pole than in the years of minimum solar activity.

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