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TABLE OF CONTENTS

CONTENTS

THE EFFECT OF THE SOLAR CYCLE ON MAGNETIC ACTIVITY AT HIGH LATITUDES

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Abstract: Magnetic activity was investigated for the period 1957 to 1966, using mean hourly ranges measured in the principal horizontal component at four Canadian magnetic observatories, and the 3-hourly range *Ap*. The maximum of magnetic activity was found to follow the solar activity maximum by about 2 years, occurring earliest in and north of the auroral zone. The maximum in each year occurred always in the auroral zone (Churchill). Enhancement of activity was greatest south of the zone (Meanook). A well defined summer maximum of activity was found in the polar cap (Resolute Bay) for all years. The annual variation for most years at auroral and sub-auroral stations showed 2 main maxima, with the dominant maximum occurring in summer or autumn. The daytime maximum of the diurnal variation tended to occur about an hour earlier during quiet years. At Churchill and at Baker Lake, on the northern edge of the auroral zone, daytime and midnight peaks of activity were found to behave differently in the period from sunspot maximum to minimum, with midnight activity generally maximum about 2 years before sunspot minimum. Results seem to confirm Lassen's (1963) model of an auroral zone made up of three separate zones.

Résumé: Les auteurs ont étudié l'activité magnétique de 1957 à 1966, en utilisant les amplitudes horaires moyennes mesurées, suivant la principale composante horizontale, à quatre observatoires magnétiques canadiens, et l'amplitude trihoraire *Ap*. Ils ont constaté que l'agitation magnétique maximale suit l'activité solaire maximale d'environ deux ans, et que le phénomène se produit tout d'abord à l'intérieur et au nord de la zone aurorale. Chaque année, le maximum apparaît toujours à l'intérieur de la zone aurorale (Churchill). La hausse d'activité a été plus grande au sude de la zone (Meanook). Au cours de toutes les années, on a trouvé un maximum estival bien défini sur la calotte polaire (baie Resolute). Pour la plupart des années, la variation annuelle a atteint 2 maximums principaux aux stations aurorales et sous-aurorales, le maximum dominant se produisant en été ou en automne. Le maximum quotidien de la variation diurne tend à se produire environ une heure plus tôt pendant des années calmes. À Churchill et Baker Lake, à la limite septentrionale de la zone aurorale, les pointes d'activité de jour et de minuit se sont comportées différemment au cours de la période entre le maximum et le minimum d'activité solaire, l'agitation magnétique de minuit étant au maximum environ deux ans avant l'apparition du minimum d'activité solaire. Les résultats semblent corroborer le modèle d'une zone aurorale composée de trois zones distinctes, dû à Lassen (1963).

Introduction

The last 11-year cycle of solar activity reached maximum and minimum values in 1958 and 1964, respectively. Simultaneous hourly range data in the principal horizontal component measured from standard-run photographic magnetograms is now available for the years 1957 to 1966 for the Resolute Bay, Baker Lake, Fort Churchill and Meanook observatories. The present paper will use this data to investigate the effect of the change from maximum to minimum value of the 11-year cycle on the diurnal and seasonal patterns of irregular magnetic activity in high latitudes.

The geographic and geomagnetic coordinates of the Canadian observatories used in this study together with the principal horizontal component recorded at each station, are listed below:

	Geographic		Geomagnetic		Principal Horizontal Com- ponent
	Lat. N.	Long. W	Lat. N	Long. E	
Resolute Bay	74.7	94.9	83.1	287.7	*Y*
Baker Lake	64.3	96.0	73.9	314.8	*X*
Fort Churchill	58.8	94.1	68.8	322.5	*X*
Meanook	54.6	113.3	61.9	300.7	*H*

The hourly range in the principal horizontal component was adopted in 1957 as a measure of irregular magnetic activity at Canadian auroral and polar-cap magnetic observatories. A physical interpretation of the use of the hourly range was given by Whitham, *et al.* (1960). The main features of the latitudinal distribution, the seasonal variations and the diurnal variation of irregular magnetic activity in Canada as given by the hourly range index have been described by Whitham, *et al.* using four months of simultaneous records from the IGY network of stations. Characteristics of irregular magnetic activity were investigated further by Loomer and Whitham (1963) using hourly range data in three orthogonal components for the year 1960 for five Canadian magnetic observatories.

The choice of hourly ranges rather than the *K*-index, based on 3-hourly ranges, had been prompted by several considerations: the impossibility of choosing a value for the lower limit of *K*9 for polar stations which would give the standard *K*-index frequency distribution; the availability of hourly range data for Russian magnetic observatories located in comparable latitudes; the apparent advantage for reasons of precision of hourly as compared with 3-hourly indices; and the fact that activity measurements at high latitudes are contaminated scarcely at all by the normal quiet-day variation. In re-examining these considerations at this time, it should be pointed out that Dr. Mayaud (1967) has since shown that it is in fact not feasible to represent the magnetic activity for the whole earth by one index, but that probably three indices are required: one each for polar, middle latitude and equatorial regions. In his extensive analysis of magnetic activity indices, Dr. Mayaud (1967) concludes that a 3-hourly index is sufficient for the global analysis of activity, but that in polar regions, the complexity of the phenomena necessitates the use of an hourly index for their study. The Berkeley meeting of IAGA later adopted a resolution calling for the measurement in two horizontal components of hourly ranges in 10-gamma units at polar observatories, to be designated as *Rx* and *Ry* indices. Recently, in an unpublished work, Johannes Wilhjelm (1967) has pointed out that the Resolute Bay data averaged over a month are not affected by the diurnal variation of the field. The diurnal effect, if present, should show up clearly in the values *Rx* minus *Ry* computed for each hour. However, the observed differences in the mean daily variations of *Rx* and *Ry* (Loomer and Whitham, 1963) cannot be explained by the phase difference in the diurnal variation of the *X* and *Y* field components.

Magnetic Activity from 1957 to 1965

As a preliminary to this investigation, the suitability of the hourly range as a high-latitude index of magnetic activity over an extended period was tested by comparison with *Ap*, the range index derived from *Kp*, which may be regarded as the standard. Unfortunately, a direct comparison between the two indices over short periods of time is difficult, since the *K*-index is based on a 3-hourly range measurement. Furthermore, the distribution of quiet days is different in northern and middle latitude regions, and *Kp* (*Ap*) is based on data from middle latitude observatories, weighted to latitude 55° approximately. Also, *Kp* is characteristically maximum at the equinoxes (Bartels, 1963) whereas an outstanding feature of the seasonal variation of activity in the polar cap is a pronounced summer maximum. However, by considering the variation of magnetic activity over a 10-year period, a valid comparison between the two indices should be possible.

To eliminate the seasonal variation of activity, which is a function of the latitude of the station, 12-monthly running means were computed from the hourly ranges, meaned each month, at the four observatories, and from the *Ap* indices for each month for the period 1957-1966. These means are plotted in gammas in Figure 1, where 1958.0 is the mean of the 12-month period beginning July 1957.

The solar flux on 2800 megacycles, similarly meaned, is also shown on Figure 1, and is a measure of the over-all solar activity. Values of *Ap* and solar flux were read from the CRPL Bulletins.

It is immediately obvious from Figure 1 that all the features of the *Ap* curve are reflected closely in the hourly range curves for the four observatories: in particular, all curves show a lag in the maximum of magnetic activity, which follows the solar activity maximum by 22 to 31 months. Altogether, there are three well defined minima and maxima of magnetic activity. All range curves show a relatively small maximum at the time of greatest solar activity, Feb-Mar, 1958. The second and dominant maximum in magnetic activity changes form fairly regularly with latitude, occurring 7 to 8 months earlier at stations in and north of the auroral zone: Sept-Oct, 1960 for *Ap*, Aug-Sept, 1960 for Meanook, Dec. 1959-Jan. 1960 for Churchill, Baker Lake and Resolute Bay. A third broad maximum occurred in 1963. This was most pronounced at

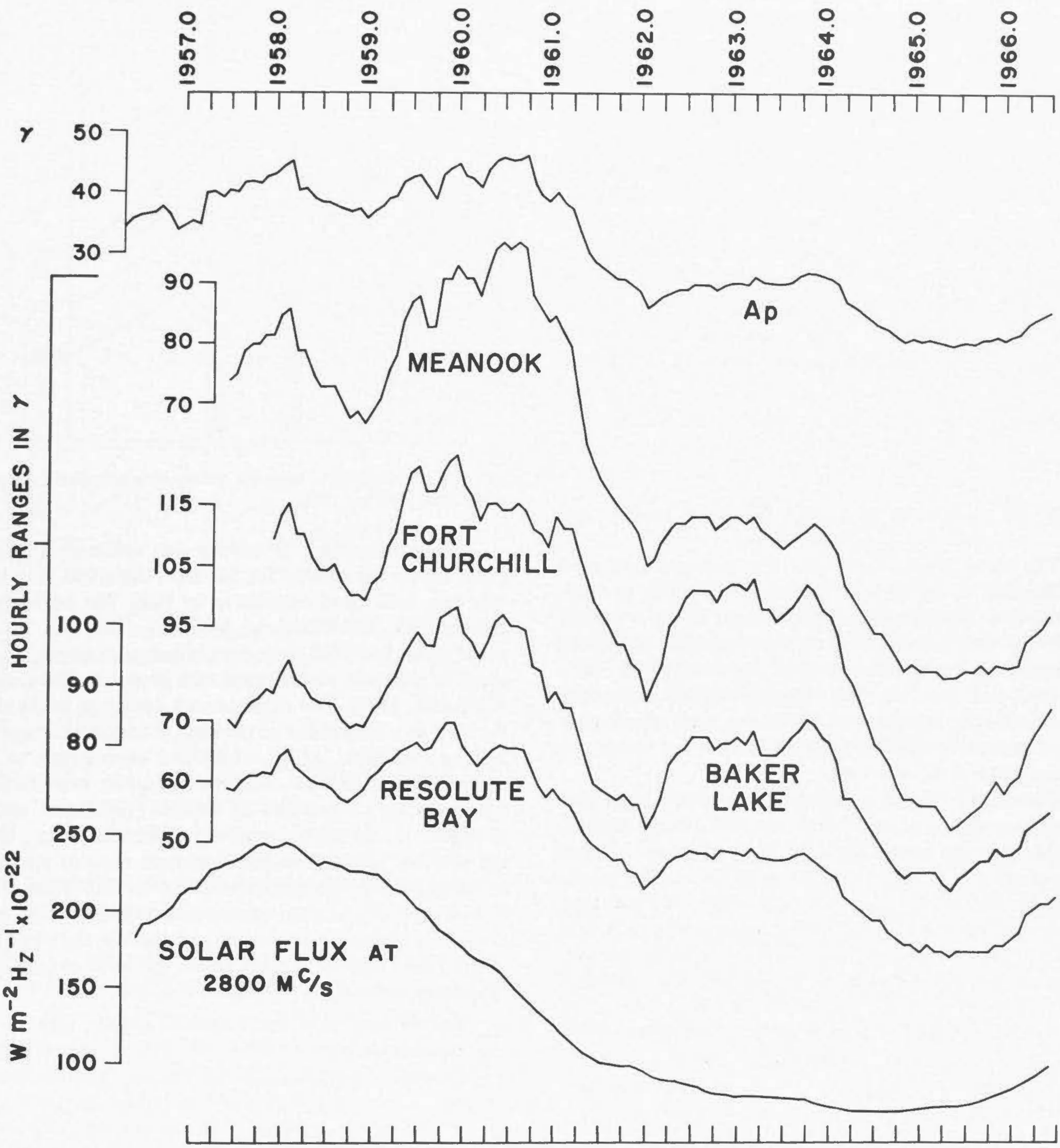

FIGURE 1. Magnetic activity corrected for seasonal (annual) variation, and smoothed solar activity, 1957 to 1966.

Churchill and Baker Lake. The first minimum was in 1959.0 for *Ap*, Meanook and Churchill, and 2 months earlier at Baker Lake and Resolute Bay. A second minimum occurred at all stations in Jan-Feb, 1962. The over-all minimum in magnetic activity was reached in May-June, 1965, about 7 months after the solar cycle minimum.

The smoothed values of the hourly ranges and *Ap* plotted in Figure 1 are very highly correlated. Table 1 gives the product moment correlation cœfficients *r* for the period 1958 to 1965 between *Ap* and the hourly ranges. The calculated values of *S*, the standard error in estimating mean hourly range values from *Ap*, are also shown.

Table 1. Correlation between Ap and Hourly Ranges

	r	*S*
Meanook	0.985	3.6%
Baker Lake	0.942	3.8
Resolute Bay	0.980	2.0

The curve of smoothed solar flux measurements does not decrease smoothly from the maximum value in 1958, but has two inflection points which occur about 6 months before the well defined onset of two intervals of enhanced magnetic activity, each lasting about 3 years: 1959.0 - Jan/Feb 1962, and Jan/Feb 1962 - May/June 1965. It is probable that this correspondence is fortuitous, since an examination of the unsmoothed solar flux data does not reveal any unusual features at these times.

The distribution of magnetic activity with latitude was investigated for the years 1958 to 1965, using the 12-monthly running means averaged for each year for each observatory and for *Ap* expressed in gammas. The graphs of the distribution for the years 1958, 1960, 1962 and 1965 are reproduced here (Figure 2). The maximum in each year occurs always at Churchill, in the auroral zone. Activity was a maximum at all stations in 1960, with the exception of Churchill where activity was 5% higher in 1959 than in 1960. An outstanding feature of the distribution curves is the great enhancement in activity at Meanook, south of the main auroral zone, in 1959 and 1960, resulting in a relatively large change in activity at Meanook from disturbed to quiet years, as is shown in the Table 2.

Table 2. Mean Annual Activity Normalized to Year 1965

	Ap	Meanook	Churchill	Baker Lake	Resolute Bay
1958	2.46	2.81	1.62	1.48	1.81
1959	2.73	3.34	1.87	1.64	2.00
1960	2.94	3.73	1.78	1.72	2.00
1961	1.85	2.34	1.55	1.26	1.52
1962	1.56	1.96	1.56	1.36	1.47
1963	1.62	1.85	1.50	1.34	1.44
1964	1.27	1.35	1.25	1.15	1.15
1965	1.00	1.00	1.00	1.00	1.00

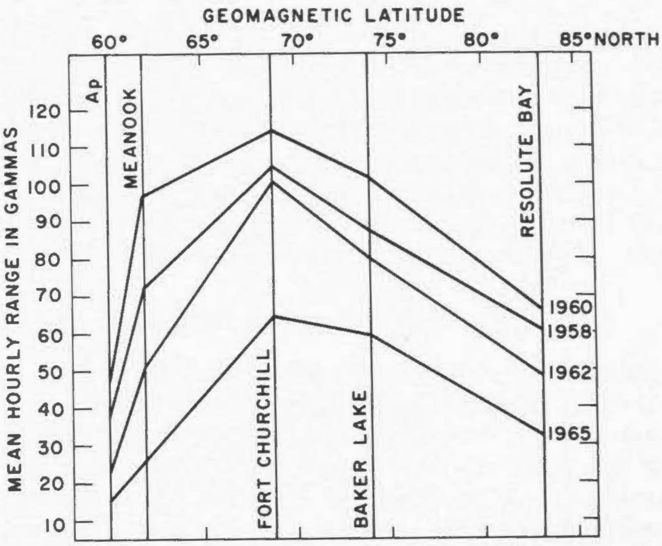

FIGURE 2. Distribution of magnetic activity with latitude for the years 1958, 1960, 1962 and 1965.

The enhancement of activity was minimum at Baker Lake, where the activity for the most disturbed year 1960 was only 1.72 times as great as in 1965. The pronounced enhancement of activity at Meanook, and also in *Ap*, could result from the movement of irregular activity to the south of the main auroral zone with increasing disturbance (Obayashi, 1959). The enhancement appeared in the data for IGY as a bifurcation of the zone of maximum magnetic activity (Whitham, *et al.*, 1960) and corresponds to the outer zone of auroral occurrence, explicit near sunspot maximum only, discussed by Lassen (1963) and shown in Figure 10. As noted previously (Whitham, *et al.*, 1960) the position of the principal maximum remains relatively constant for all years considered. The relatively low ratios in and north of the main auroral zone reflect the high level of activity during quiet periods, and the low disturbed day to quiet day ratio of activity, inside the polar cap, relative to sub-auroral regions (Whitham, *et al.*).

The variability of the magnetic activity may be expressed as the sum of the differences without regard to sign of successive 12-monthly running means. Variability curves for each of the observatories and for *Ap* for the years 1958 to 1965 are shown in Figure 3. In interpreting these curves it must be remembered that the seasonal variation has already been removed by the method of averaging.

All stations show an increase in variability in 1964 owing to the rapid decrease in activity during this year. Variability remains high at Churchill and Baker Lake for all years. The change in variability is greatest for Meanook, where the ratio of maximum to minimum is about 6, and least in the auroral zone where the ratio is about 2. This result is to be expected from the frequent occurrence of magnetic activity during nominally quiet periods in the auroral zone. For the 8 years considered, the variability was 12 gammas for *Ap*, 23 gammas for Meanook, 25 gammas for

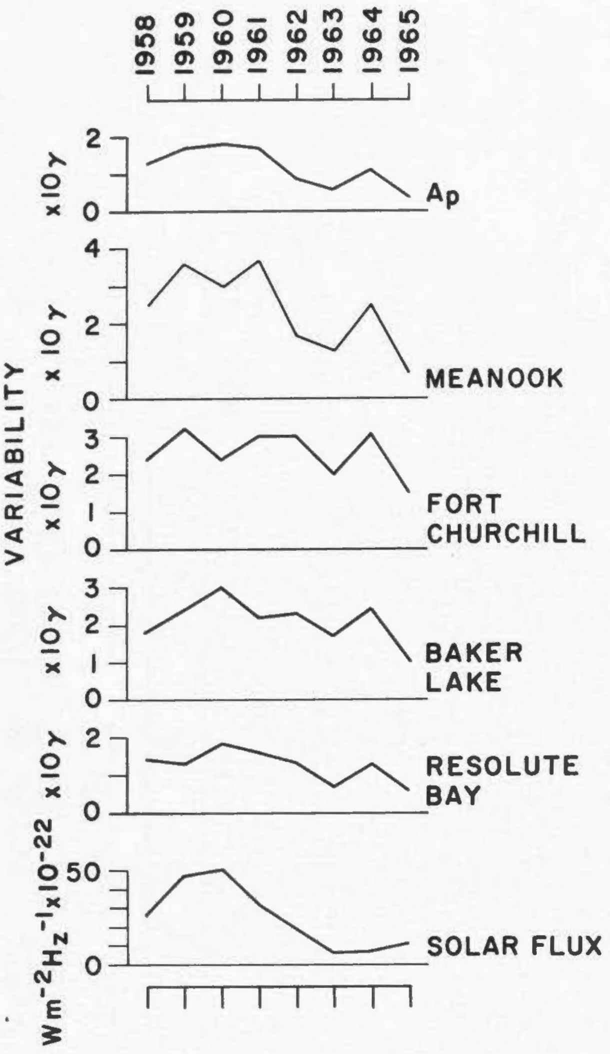

FIGURE 3. Variability of magnetic activity and solar flux, 1958 to 1965.

Churchill, 21 gammas for Baker Lake, and 13 gammas for Resolute Bay. The distribution of the variability of activity and the intensity of activity are thus quite similar, with maximum at Churchill in the auroral zone, and minima at the middle latitude station represented by *Ap*, and at Resolute inside the polar cap.

The variability of the smoothed solar flux, calculated in a similar way, is also shown in Figure 3. The curve has a maximum in 1960, the year of maximum magnetic activity; if the unsmoothed data are used, the greatest values occur in 1957 and 1959, one year before and after the solar flux intensity maximum.

Summary

A comparison between the hourly ranges from four observatories and *Ap* has confirmed that the hourly ranges can provide a satisfactory measure of activity at high latitudes over an extended period of time, provided that the seasonal variation of magnetic activity is removed from the data. The hourly ranges used were representative of the polar cap, auroral and sub-auroral regions. In all cases, they correlated very highly with *Ap*. The magnetic activity maximum followed the solar maximum by about 2 years, and occurred earliest in and north of the auroral zone. The minimum of magnetic activity followed the solar minimum by about 7 months. The well defined intervals of enhanced magnetic activity followed inflection points on the smoothed solar flux curve by about 6 months. On the average, the intensity and variability of magnetic activity are greatest at Churchill, in the auroral zone, and least at Resolute Bay in the polar cap, and for *Ap*, which may be regarded as corresponding to a middle-latitude station at approximately 55°.

The Seasonal Variation of Magnetic Activity for the Period 1958–1965

The seasonal variation was derived by subtracting from each 12-monthly running mean of magnetic activity, the average activity measured for the months preceding and following the point in time corresponding to the 12-monthly mean. This may be expressed as

$$S = 1/2(R_{k+5} + R_{k+6} - 1/2 \sum_{n=k}^{n=k+11} (R_k)$$

where S is the seasonal variation centred on the 2-month period $k+5$ to $k+6$, and R_k is the mean hourly range for month k, where k is integral and ≥ 1. For example, if $k=1$ refers to July 1957, the mean for the 12-month period beginning July 1957 minus ½ (December 1957 average hourly range plus January 1958 average hourly range) gives the seasonal variation corresponding to December 1957 - January 1958. For convenience, this is labelled January 1, 1958, or 1958.0 on the graphs.

Curves of seasonal variation for *Ap* and for the hourly ranges at the four observatories are shown in Figure 4.

Certainly the most outstanding feature of these curves is the persistent well defined summer maximum of activity at Resolute Bay. In general, the maximum of activity at Resolute Bay appears in June/July. In 1960 this maximum is shifted 1 month earlier. In 1963 the curve has a broad peak extending over 4 months centred on July. Small secondary maxima are seen in the spring of 1958 and 1959, and in the fall on 1960. These small maxima, and the enhanced activity in the spring and autumn of 1962 to 1964, as seen in a broadening of the curves for these years, are apparently a result of equinoctial activity in the auroral zone.

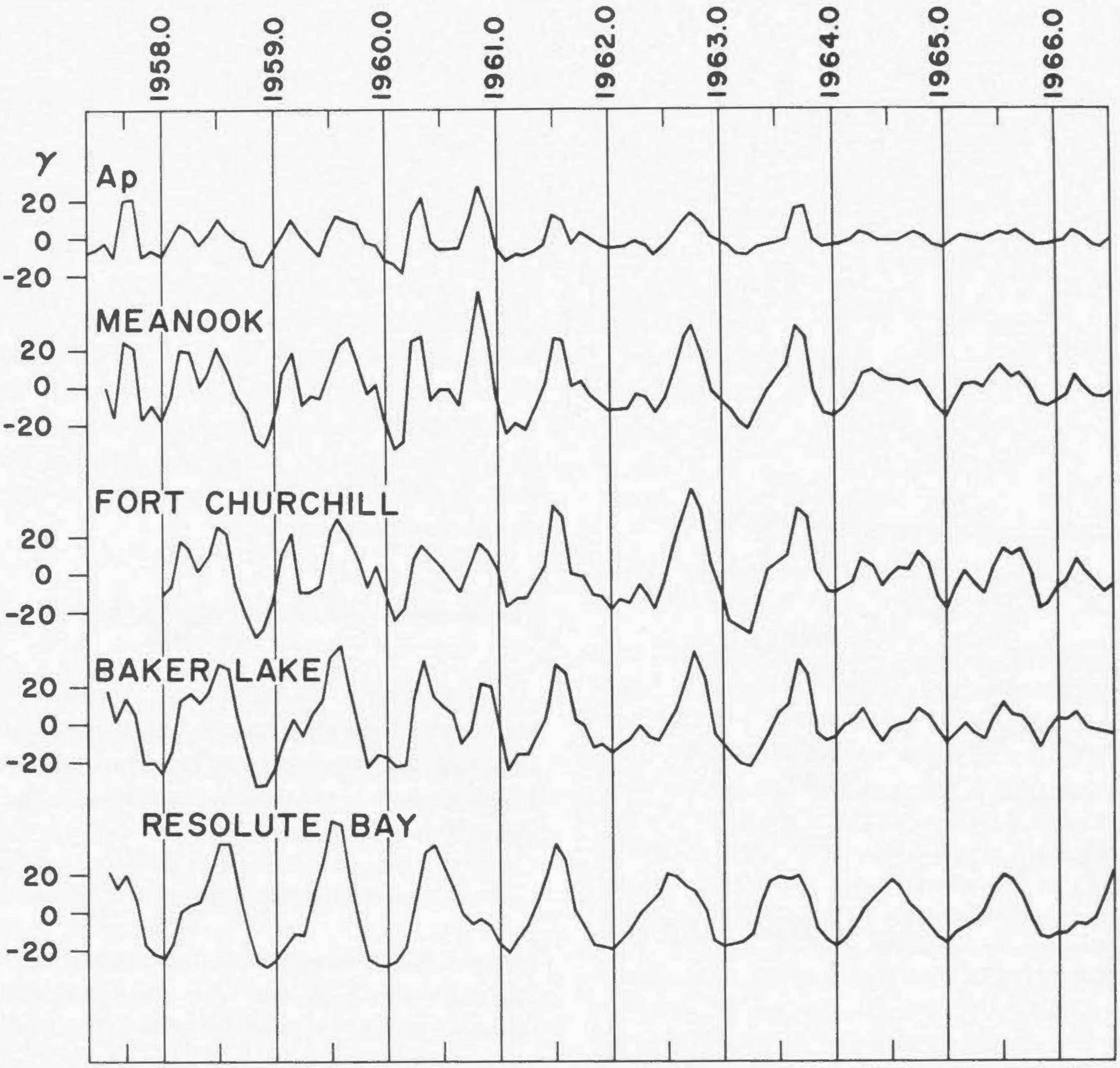

FIGURE 4. Seasonal (or annual) variation of magnetic activity.

The double-peaking referred to by Bartels and other writers in discussing *Kp* is evident in the seasonal variation for most years at locations south of Resolute Bay, and particularly at Churchill and Meanook and in *Ap*. Baker Lake appears most clearly as a transition station in 1958 and 1959; for the other years, the seasonal variation at Baker Lake is of the auroral zone type rather than the Resolute Bay, or polar cap, type. In 1961 the June/July peak in activity characteristic of Resolute Bay is dominant at all stations. Several authors, for example Mayaud (private communication), have drawn attention to the abnormal character of magnetic activity during November 1960. This is evident in Figure 4.

On the average, during the years of decreasing activity, there seems to be a relative enhancement of activity during the summer and fall months. With the sole exception of 1964, the main maximum of activity always occurs in either the fall or summer at all locations. A spring maximum is prominent only at stations south of Resolute Bay, and only in 1958-1959 and 1964-1965, around the times of solar maximum and solar minimum.

The range of the seasonal variation (maximum - minimum) for each year is shown in Figure 5. The enhancement of activity in 1960 at Meanook and in *Ap* is very evident. For the years 1958 - 1965, the average range of seasonal variation of activity is greatest at Resolute and appears to decrease with decreasing latitude. The variability of the seasonal variation was also calculated, in the same manner as for the annual values derived from 12-monthly running means (see "Magnetic Activity from 1957 to 1965"). As expected, the variability (Figure 6) and the actual range (Figure 5) of the seasonal variation are closely correlated. Variability was a maximum at Churchill and a minimum for *Ap*. The variability, or change from month to month in activity, would appear to be a more meaningful measure than the simple difference between maximum and

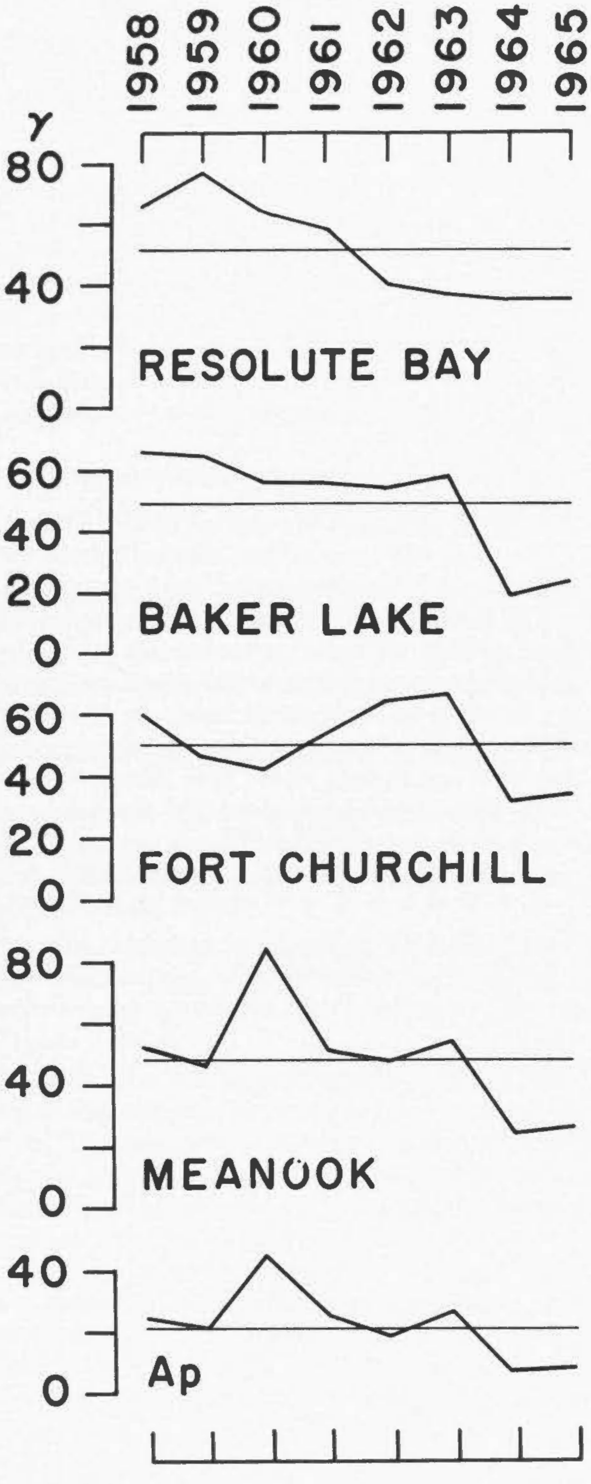

FIGURE 5. Range of seasonal variation of activity.

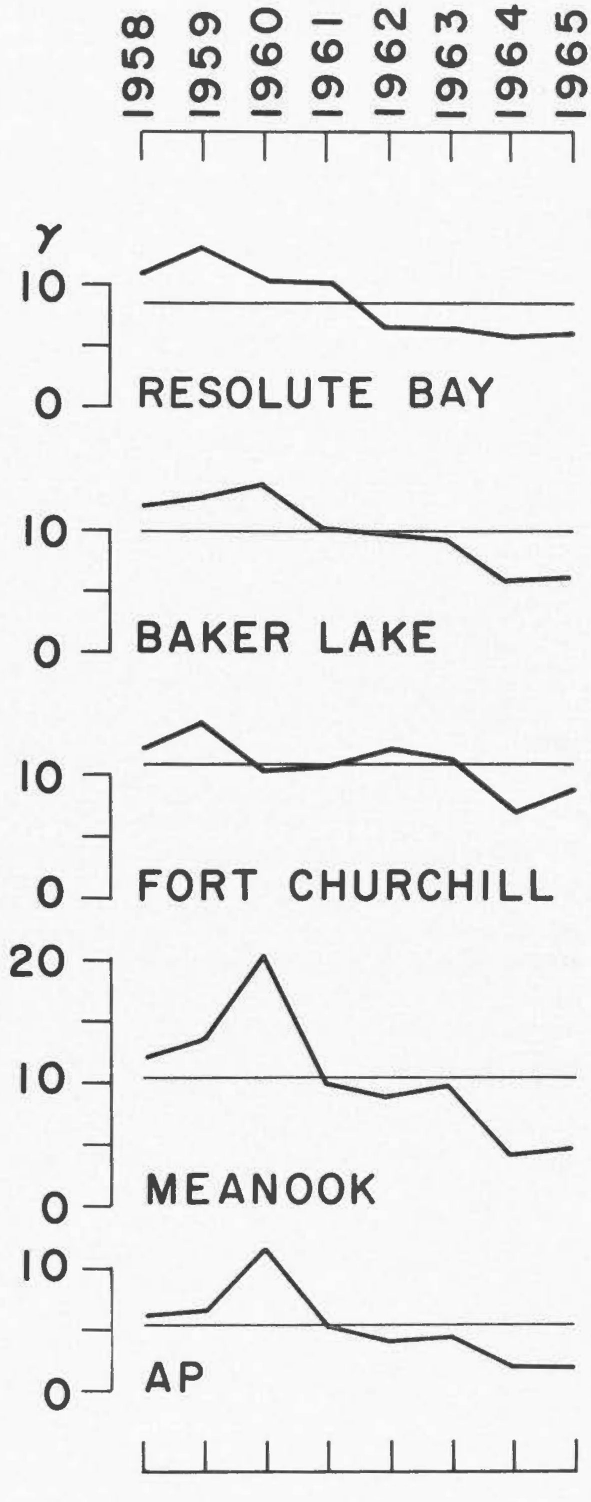

FIGURE 6. Variability of the seasonal variation of activity.

minimum each year, owing to the complex form of the seasonal variation at Baker Lake, Churchill, Meanook and for *Ap*, as compared with Resolute Bay. If the variability values are arranged by month and averaged over the years 1958 to 1965, the main maxima are found to occur always in the summer or autumn at all stations, with secondary winter and spring maxima significant only at Churchill and to the south.

Summary

For the period investigated, activity at Resolute Bay in the polar cap has a pronounced summer maximum in all

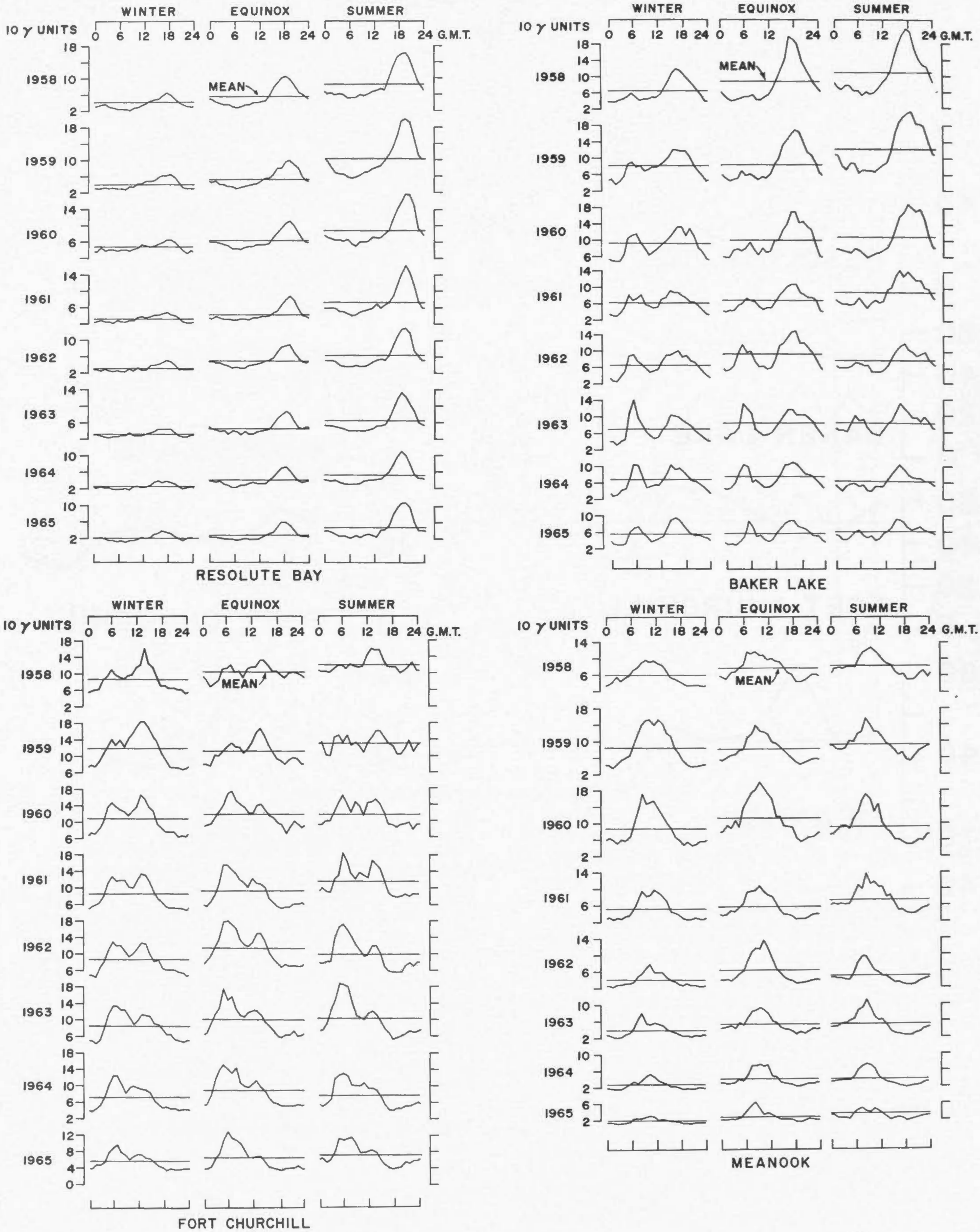

FIGURE 7. Diurnal variation of magnetic activity by year and season, for Resolute Bay, Baker Lake, Fort Churchill and Meanook.

years. Most years at auroral and sub-auroral stations show two main maxima, but the dominant maximum occurs with very few exceptions during the summer or autumn. Spring maxima are noticeably suppressed in the years 1961 - 1963.

The greatest difference between extreme values of seasonal variation during the year is found on the average at Resolute Bay; however, the variability of seasonal change is maximum at Churchill. Maximum variability occurs at all stations during the summer and fall. A very close relationship does not hold between the range or variability of the seasonal variation, and the average level of activity, although the maximum and minimum of the range and variability of seasonal variation occur within a year of the maximum of the general magnetic activity.

Diurnal Variation for the Years 1958 to 1965

The diurnal variation of magnetic activity was derived for winter, equinox and summer for each year for each observatory, from the hourly ranges measured in the principal horizontal component. It was shown in a previous paper that the diurnal variation for different components is similar at high latitudes (Loomer and Whitham, 1963). The curves of diurnal variation shown in Figure 8 generally support the broad conclusions reached in previous investigations (Whitham, *et al.*, 1960; Loomer and Whitham, 1963): that magnetic activity is maximum around noon in the polar cap, and around midnight south of the auroral zone, and exhibits both a daytime and night-time maximum in the intervening region.

The diurnal variation curves for 8 years' data for the four observatories, arranged according to season, together with average curves for each observatory, are shown in Figures 7 and 8.

The noon maximum of activity at *Resolute Bay* shows the strong summer enhancement noted in earlier investigations. The average level in summer is over twice as great as that in winter, and the average equinoctial level is 67% higher than the winter mean. The times of maximum in the equinox and summer are 1 hour and 2 hours later, respectively, than in winter, when the maximum occurs on the average at 17 - 18 UT. In the quiet years 1963 - 1965 the daytime maximum is significantly broader in the winter, and occurs about 1 hour earlier in all seasons than for the disturbed years 1957 - 1962. A small but apparently persistent maximum also shows at 1 - 2 hours UT during the winter.

The daytime maximum at *Baker Lake*, around 16 - 17 UT, shows no persistent change in time of occurrence with season, but tends to be earliest in winter in most years. It increases in amplitude from winter to summer, whereas the night-time maximum is greatest in the winter and least in the summer. The night-time maximum appears on the average 1 hour earlier in summer than in winter, when the average time of occurrence is 5 - 6 UT. A flattening of the average curves (Figure 8) a few hours after the daytime

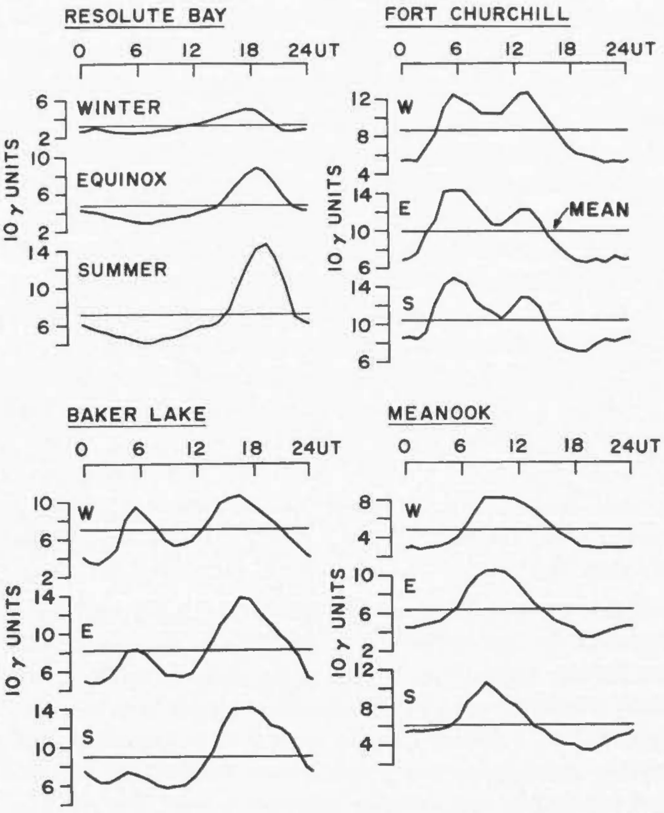

FIGURE 8. Average curves of diurnal variation, 1958 to 1965.

maximum is evident in the summer and perhaps in the equinox also, at a time corresponding to the time of the Resolute Bay maximum. This flattening is a result of the double-peaking seen on the curves for individual years. Over-all activity is greatest in summer, when it is about 25% greater than in winter. As at Resolute Bay, the activity is minimum in winter. Only the daytime maximum shows a consistent shift in time of occurrence with magnetic activity, occurring 1½ hours earlier during the quiet years 1965 - 1966 than in the more disturbed years 1957 - 1964.

At *Fort Churchill* the average times of occurrence of the night-time and daytime peaks of activity for the years considered are 5 - 6 and 12 - 14 UT, respectively. No persistent change with season is evident. Multiple peaking of the night-time activity is very noticeable in the years 1958 - 1960, and particularly during the summer months. Night-time activity is maximum in summer and minimum in winter, but the over-all change is only 16%. The daytime maximum has approximately the same level in all seasons, to within a few per cent. A small maximum occurs on the average between 21 and 23 hours UT in the equinox and summer in most years. Over-all activity is least in winter. It is greatest on the average in summer, although equinoctial values were slightly larger than the summer values in 1960, 1962 and 1964. The average increase in the over-all activity from winter to summer is about 20%. As at Baker Lake, only the daytime maximum shows a consistent shift in time of occurrence with magnetic activity, occurring about 1 hour earlier during the quiet years 1965 - 1966.

The diurnal variation curves for *Meanook* are more irregular in form than those for the more northern observatories, but a maximum in activity around local midnight is the dominant feature of the curves for all seasons for the years 1958 - 1965. As seen in the summary curves, this peak is broad in the winter (08 - 11 UT) and sharp in the summer (8 - 9 UT), suggesting that the night-time maximum occurs earliest in summer. The broadening of the maximum in winter is a consequence of the double-peaking evident on the winter curves for most years. Average activity is least in winter and nearly equal in the equinox and summer, when it is 27% higher than the winter mean. The average curves show a well defined minimum in the equinox and summer at 18 - 20 UT. The maximum of activity shows no consistent shift in time of occurrence from year to year for the period investigated.

An interesting feature of the Baker Lake and Fort Churchill diurnal variation curves is the increase in amplitude of the night-time relative to the daytime peak as the over-all level of activity changes from maximum to minimum. Figure 9 shows a plot by season of the night-time and daytime activity for the years 1958 - 1966 for Baker Lake and for Churchill. Average curves are also shown. The ordinate is the sum of the hourly ranges meaned for each month for the 5 hours centred on the maximum night-time or daytime value. The graphs for the two stations are quite similar. The daytime activity is a maximum in 1958 - 1960, the period when magnetic activity was greatest, and a minimum in 1965, and thus follows approximately the curve for the over-all level of magnetic activity (Figure 1). A second smaller peak occurs in the year 1962 or 1963. The night time activity, which is associated with visible aurora at these stations, also reaches above average values in the years 1962 - 1963 and 1959 - 1960. However, the dominant maximum occurs in 1962 - 1963, except during the winter when the greatest night-time activity was in 1959 and 1960.

Lassen (1963) has demonstrated the similarity between the daily distribution of magnetic activity and auroral frequency, except in very high latitudes. Comparing the daily variation of the hourly ranges of H at Godhaven (geomag. lat. 79.8°) in September – March near sunspot minimum (1932-1933) and near sunspot maximum (1927-1928), he found that magnetic activity near midnight is greatly enhanced at sunspot minimum. He has explained this as the result of a movement of the inner auroral zone to the north in sunspot minimum years with a corresponding increase in the frequency of aurora in this zone. His schematic diagram showing the assumed distribution of auroral frequency along the magnetic meridian during night hours is reproduced in Figure 10. The positions of Meanook, and Baker Lake in Mayaud magnetic latitude (Mayaud, 1967) have been added to this figure. According to Lassen's model, the effects at Baker Lake and Godhaven

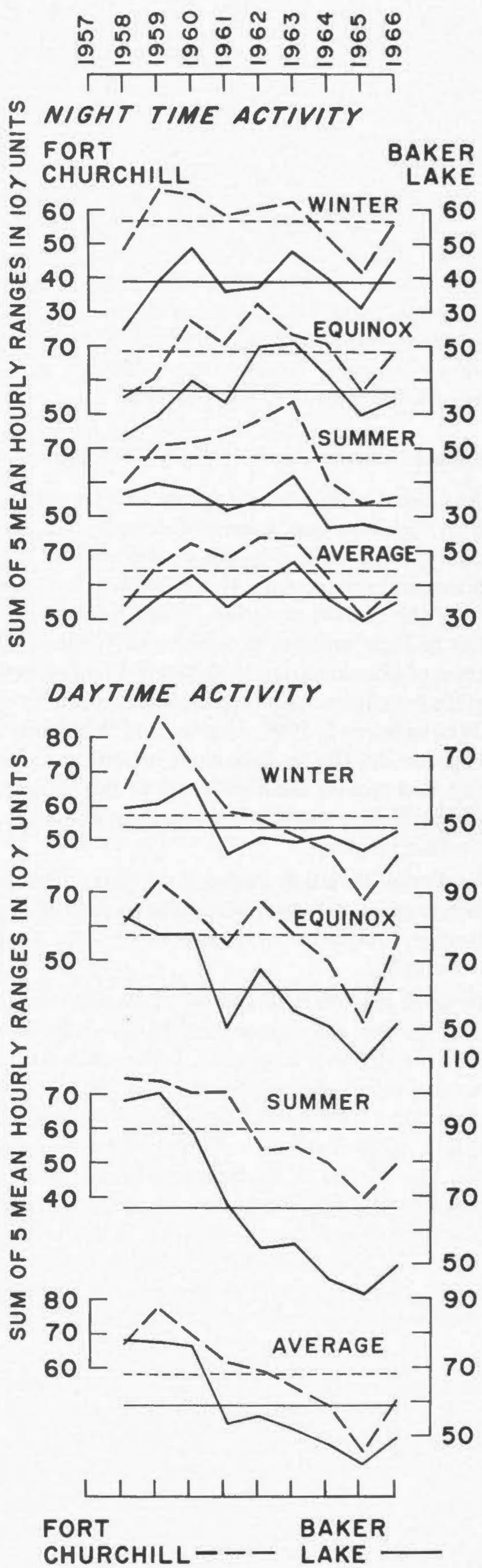

FIGURE 9. Comparison by season of night-time and daytime activity at Fort Churchill and Baker Lake, 1958 – 1966.

should be very similar. At Churchill also the auroral frequency is greater at sunspot minimum, by a factor of about 3, according to frequencies given by Davies for 1943 – 1948. From this model it would be expected that magnetic activity around midnight, which is strongly related to auroral sub-storms (Lassen, 1958), would be maximum at Baker Lake and Fort Churchill at sunspot minimum. However, from Figure 9, the night-time activity reaches maximum values about two years before sunspot minimum, and two years following sunspot maximum, periods when the general level of magnetic activity was high (Figure 1).

The model indicates a marked shift of the outer auroral zone to lower latitudes at sunspot maximum, when the outer zone is located in the vicinity of Meanook. Figure 2 shows the increase in level of magnetic activity at Meanook in 1959-1960. From Figure 8, night-time activity at Meanook is seen to be greatest in these years, and least around sunspot minimum, as predicted by the model.

The daytime activity at Baker Lake increases from winter to summer by about 30%, but is almost constant for the three seasons at Fort Churchill. Night-time activity increases about 20% at Churchill from winter to summer, but at Baker Lake night-time activity is greatest in winter, decreasing slightly through the equinox to a minimum value in the summer. This is in fair agreement with the distribution given by Lassen (1963) of auroral frequency at Baker Lake along the magnetic meridian during night hours of 1957-1958 for equinox and winter. However, the winter frequency is shown as almost twice the equinox frequency, whereas the magnetic activity around midnight in 1958 (Figure 7) as well as in the average for 1958 – 1965 (Figure 8) is only a few per cent greater in the winter. Contrary to the auroral frequency distribution, the winter value of magnetic activity around midnight at Fort Churchill is less than for the equinox both in 1958 and in the average for 1958 – 1965. This discrepancy had been noted by Lassen (1963) in his comparison with magnetic data from 1932-1933, and was attributed to uncertainty in the magnetic data in the interval 70 – 75°. Lassen explains the change with season of auroral frequency and magnetic activity by a combination of variations in the intensities of the maximum of auroral occurrence and oscillations of the polar distance of the auroral zones. At Meanook, both the magnetic activity and the auroral frequency are less in winter than in the equinox.

Summary

The phase of the diurnal variation of magnetic activity at all observatories is remarkably constant over the period investigated. The daytime maximum at all stations tends to occur an hour or so earlier during quiet years. The time of the night maximum does not appear to change consistently with the level of activity.

The diurnal variation at Resolute Bay has a pronounced maximum around local noon (18 UT). The noon peak is greatly enhanced during the summer, and in disturbed years, and is apparently not related to auroral activity.

At Baker Lake and Fort Churchill the diurnal variation has both a daytime and a night-time maximum. At both stations the night-time maximum is close to local midnight. Daytime activity is maximum around 16 – 17 hours UT at Baker Lake, and 12 – 14 UT at Fort Churchill. The daytime and midnight peaks at both stations behave differently in the period from sunspot maximum to minimum, and activity is distributed differently between the day and night regimes at the two stations. In particular, midnight activity, which is strongly associated with visible aurora, is maximum in most cases about 2 years before sunspot minimum. At Meanook, south of the main auroral zone, the diurnal variation has a single maximum, around local midnight.

The results pertaining to midnight activity have been compared with the frequency of occurrence of night-time aurora as given by Lassen (1963), and some significant differences have been noted. In particular, magnetic activity around midnight at both Baker Lake and Fort Churchill is greatest about 2 years before sunspot minimum, and not at the time when frequency of occurrence of aurorae is maximum. A second maximum in night-time activity occurred in 1959-1960 when the over-all level of magnetic activity was greatest. This second maximum was dominant in the winter months at both stations. However, this may be a result of the high level of magnetic activity in these years. For if, instead of plotting the actual values of night-time activity at Baker Lake for the 5 hours centred on the time of maximum, as in Figure 9, we plot the amplitude of the midnight peak from a mean level obtained by drawing a straight line between the minima preceding and following the midnight peak, the 1959-1960 maximum decreases sharply relative to the 1963 maximum. This is shown in Figure 11. In this figure the variation of the noon maximum, similarly measured, is also shown for 1957 – 1965, and is seen to follow more closely the solar cycle than the comparable curves in Figure 9. Unfortunately the Churchill diurnal variation curves (Figure 7) are too irregular to be easily measured in this way, but it can be assumed that the variation of night-time activity with the solar cycle will be similar to that at Baker Lake.

A second discrepancy between the behaviour of magnetic activity around midnight and the frequency of occurrence of aurora is in the increase of magnetic activity at Fort Churchill from winter to equinox. This confirms the discrepancy noted earlier by Lassen for the years 1932 – 1933, and hence is unlikely to be a result of uncertainty in the magnetic data in the interval 70 – 75°.

However the behaviour of magnetic activity around local midnight at Baker Lake, Fort Churchill and Meanook and the marked increase in the over-all level of activity at

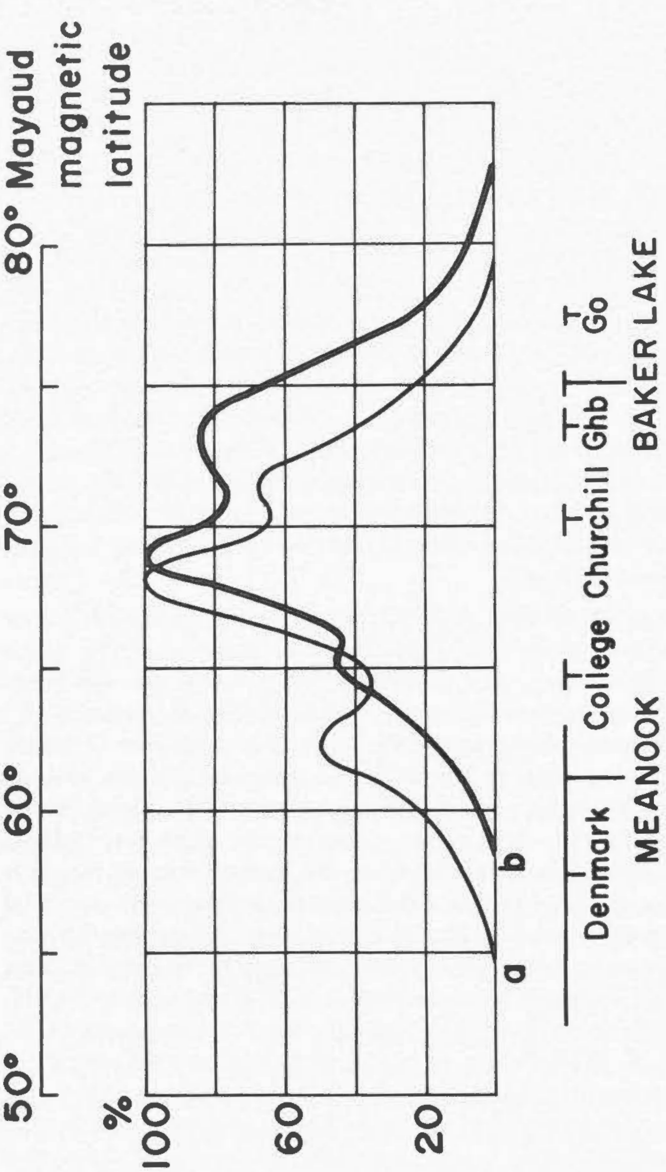

FIGURE 10. Assumed distribution of auroral frequency along the magnetic meridian during night hours (from Lassen).

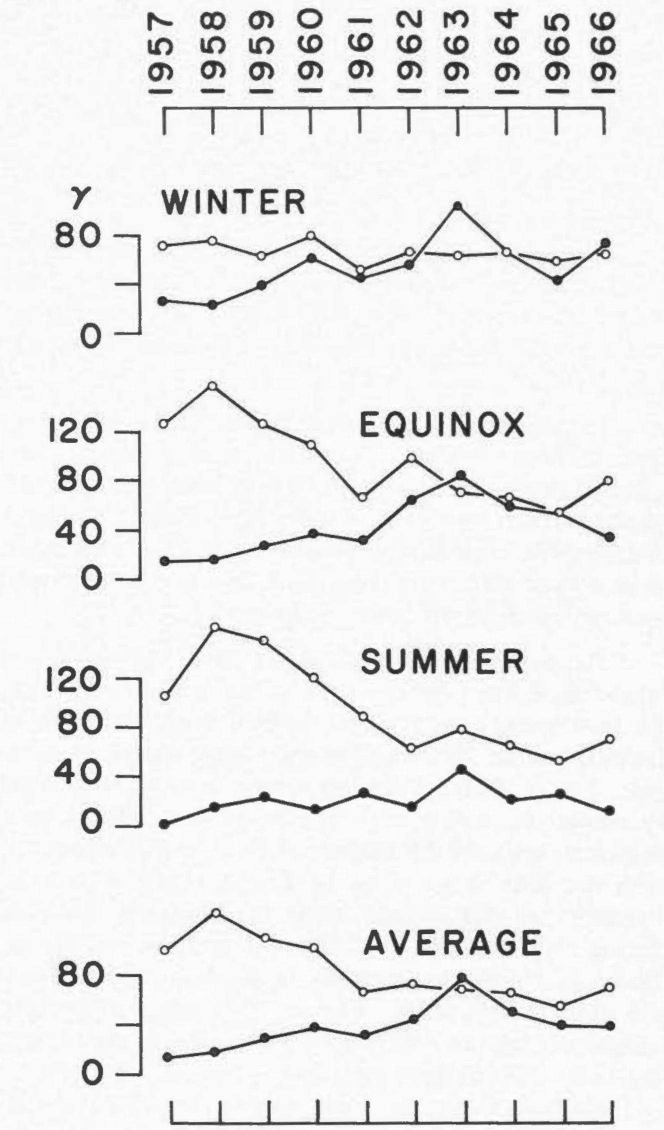

FIGURE 11. Comparison by season of midnight and noon peak of activity, Baker Lake, 1958 - 1966. Midnight peak —●— Noon peak —○—

Meanook in 1959-1960 generally indicate the great similarity between magnetic activity and the occurrence of visible aurora in these latitudes and confirm the model given by Lassen (1963) of an auroral zone made up of three separate zones, as shown in Figure 10.

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