Auroral E_s and Blackout under the Ionospheric Observation

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電離層観測における Auroral E_s と Blackout について

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要　旨

1960年1月から1961年1月に至る第4次南極越冬期間中に昭和基地で行なった電離層観測資料から，主として E 領域における Auroral E_s と Blackout について解析を行なった．

Auroral E_s の季節変化は冬期の 6~8 月に出現頻度が高く，11~12月が最も少ない．出現時刻は年間を通じてほぼ一定しており，出現率の高い時間は 23.00ʰ~03.00ʰ (LT) の間である．これらの高さは 110 km 付近が最も多く，Auroral E_s の最高周波数は 3~5 Mc 付近で常に散乱をともなっている．

Blackout の発生率は年間を通じて非常に多く，12月~3月の夏季を除いて，ほとんど 30% 近くの頻度を示している．09.00ʰ~10.00ʰ (LT) に first peak があり，冬季の 6 月~8 月には 20.00ʰ~21.00ʰ (LT) に異常に高い second peak が出る．これは，季節的変化として，磁気緯度と密接な関係にある．

Introduction

Analysis was made on the auroral E_s and blackout, mainly in the E region, from the data of the ionospheric observations carried out all the year round at Syowa Base during the fourth Antarctic Research Expedition from 1960 to 1961.

In the seasonal variation of the auroral E_s the frequency of occurrence is the highest in June to August in the winter season. The auroral E_s has a recurrence tendency and, on the occasions of disturbance such as magnetic storms, is seen all the less on account of a continuance of blackout of long duration. Throughout the year it occurs almost at a definite time of the day and the occurrence rate is very high between 2300 and 0300 hours (LT). Its height is nearly 110 km. Most have the highest frequency of 3 to 5 Mc/s. The occurrence rate of blackout is as high as about 30% except in the summer between December and March. All the year around, the first peak appears in the vicinity of 0900 to 1000 hours (LT) and the second peak is extraordinarily high at about 2000 to 2100 hours (LT) between June and August in the winter. This is in close relation to the magnetic latitude.

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1. E_s layer

The E_s layer in the vicinity of Syowa Base is subject to wide variations and is very unstable throughout the year. In the daytime in summer, as in medium latitudes, the E_s layer observed is mostly of *l* or *c* type and sometimes the highest frequency reaches nearly 15 Mc/s. A unique characteristic of the E_s layer in the summer, however, is that even the highest frequency hardly shields the *F* region. Therefore, the E_s layer in the daytime may be said to be very small in thickness and poor in absorption. An example of diurnal variation during the summer is shown in Fig. 1.

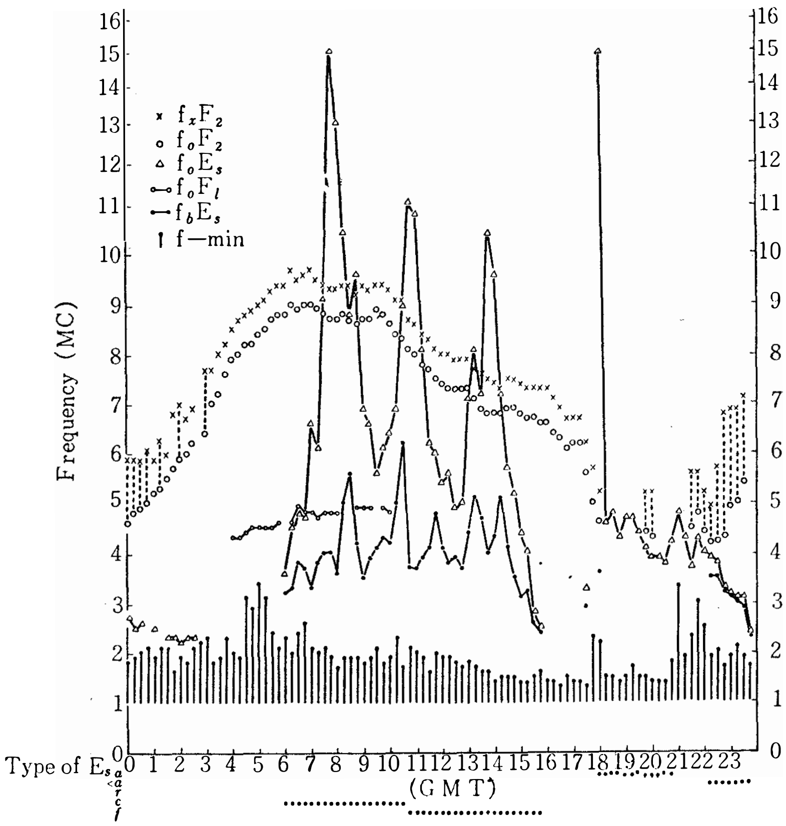

Fig. 1. f-Plot of ionospheric data. Feb. 11, 1960. Syowa Base.

2. Auroral E_s

This is the ionospheric reflection following the appearance of an aurora, a peculiar phenomenon in polar regions, and is characterized by scattering due to irregularities in the layer. The time of appearance mostly falls in the night throughout the whole year and the waves reflected may be classified into the auroral E_s of about 110 km and the auroral F_s of more than 200 km, depending on the nature of the aurora. At Syowa Base where the frequency of appearance of auroras is the heighest, the auroral E_s has a very high rate of occurrence.

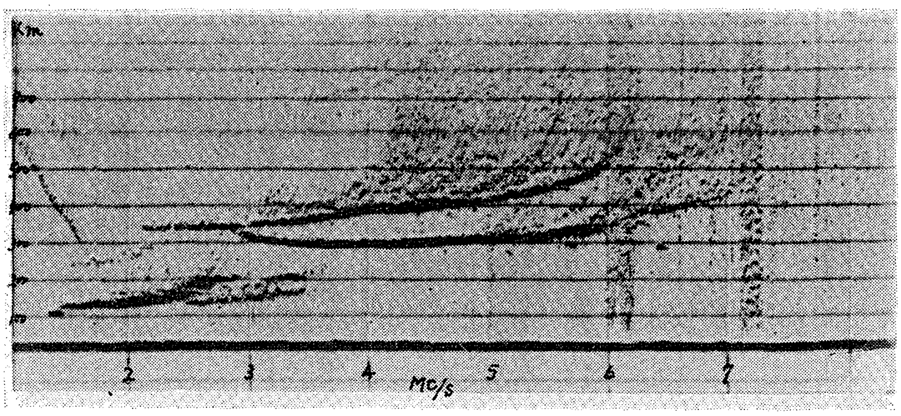

Fig. 2. Sample of auroral F_s. 22:45, Feb. 13, 1960.

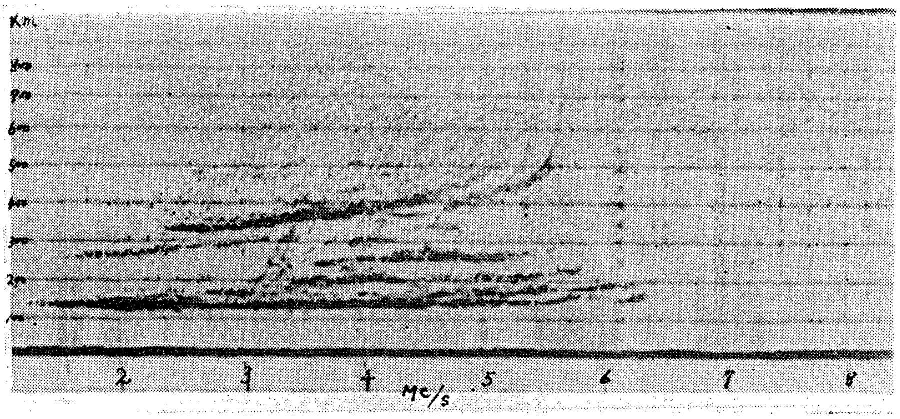

Fig. 3. Sample of auroral E_s. 01:00, July 10, 1960.

3. Features of auroral E_s

At the beginning of the occurrence of the auroral E_s the absorption in the F region comes to increase and there appears the E_s of r type. This gradually develops into scattering and is changed into the auroral E_s. Some scattered seriously extend over several hundred kilometers. During the period from the start to the end of the auroral E_s, the scattered layer changes several times and varies in height considerably. In considerably many cases, depending on the frequency of reflected waves, two or three different layers appear in a short space of time. However, at the beginning of the start of the E_s of r type, partly owing to the irregularity in the layer due to the sunset effect, there are in many cases difficulties in distinguishing the night E_s layer from the E_s of r type in specially low frequency bands. The relation with the auroral E_s is complicated, too. Such phenomenon is often noted at sunrise and sunset in the winter season.

4. Nature of auroral E_s

Fig. 4 shows the frequency of appearance per month at Syowa Base. The rate of appearance is high in the winter between June and August and has a tendency to descend in the summer from November till January.

A look at these hours appearance makes clear that throughout the year there are variations in frequencies, but the hours remain almost unchanged. The auroral E_s begins to appear at about 1900 hours (LT), reaches the peak between 2300 and 0300 hours (LT), and disappears at about 0600 hours (LT). The time of disappearance varies considerably with seasons. Therefore, the duration is much longer in winter than in summer. The hours 2300 to 0300 (LT), comparatively high in the rate of appearance, are plotted by months in Fig. 5, where the rate is highest at 0100 hours (LT). From the visual observation of auroras, the frequency of appearance is very high between 2330 and 0030 hours (LT), but no comparative study has yet been made of the actual data.

The seasonal tendency is that the

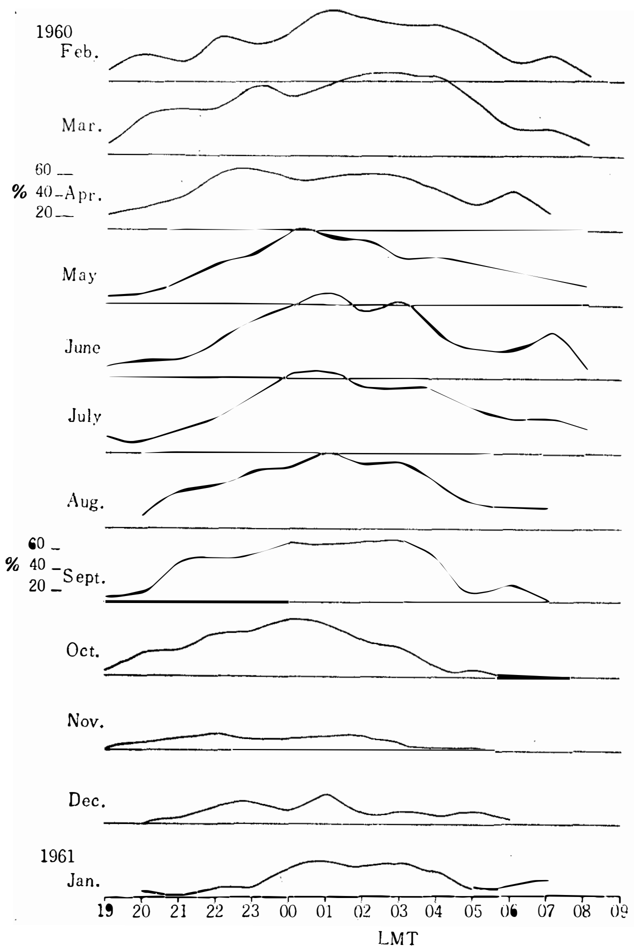

Fig. 4. Frequency of appearance of auroral E_s.

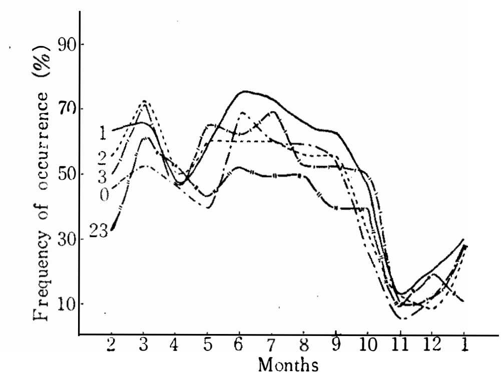

Fig. 5. Seasonal variation of auroral E_s.

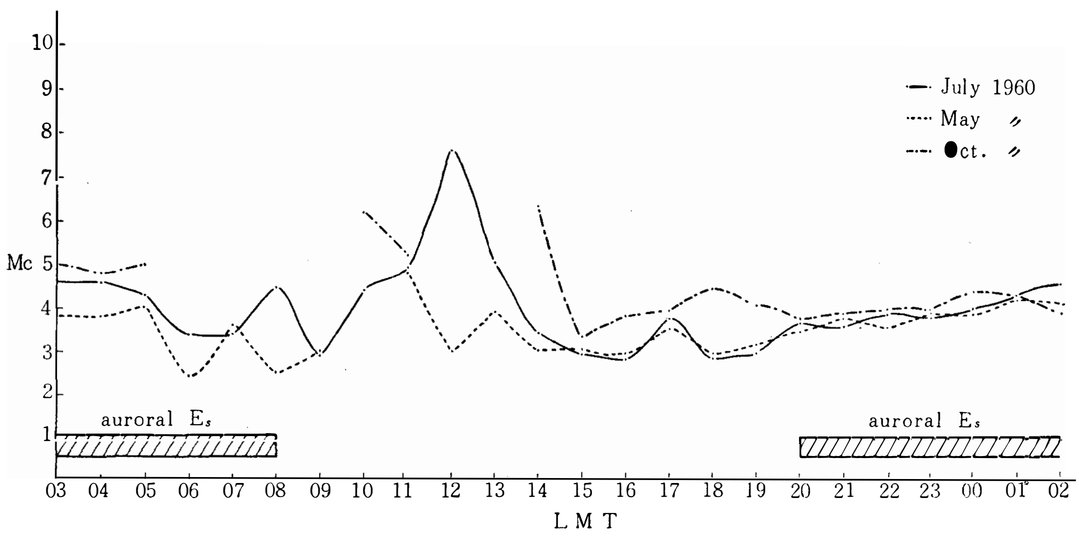

Fig. 6. Monthly median values of f_0E_s at Syowa Base.

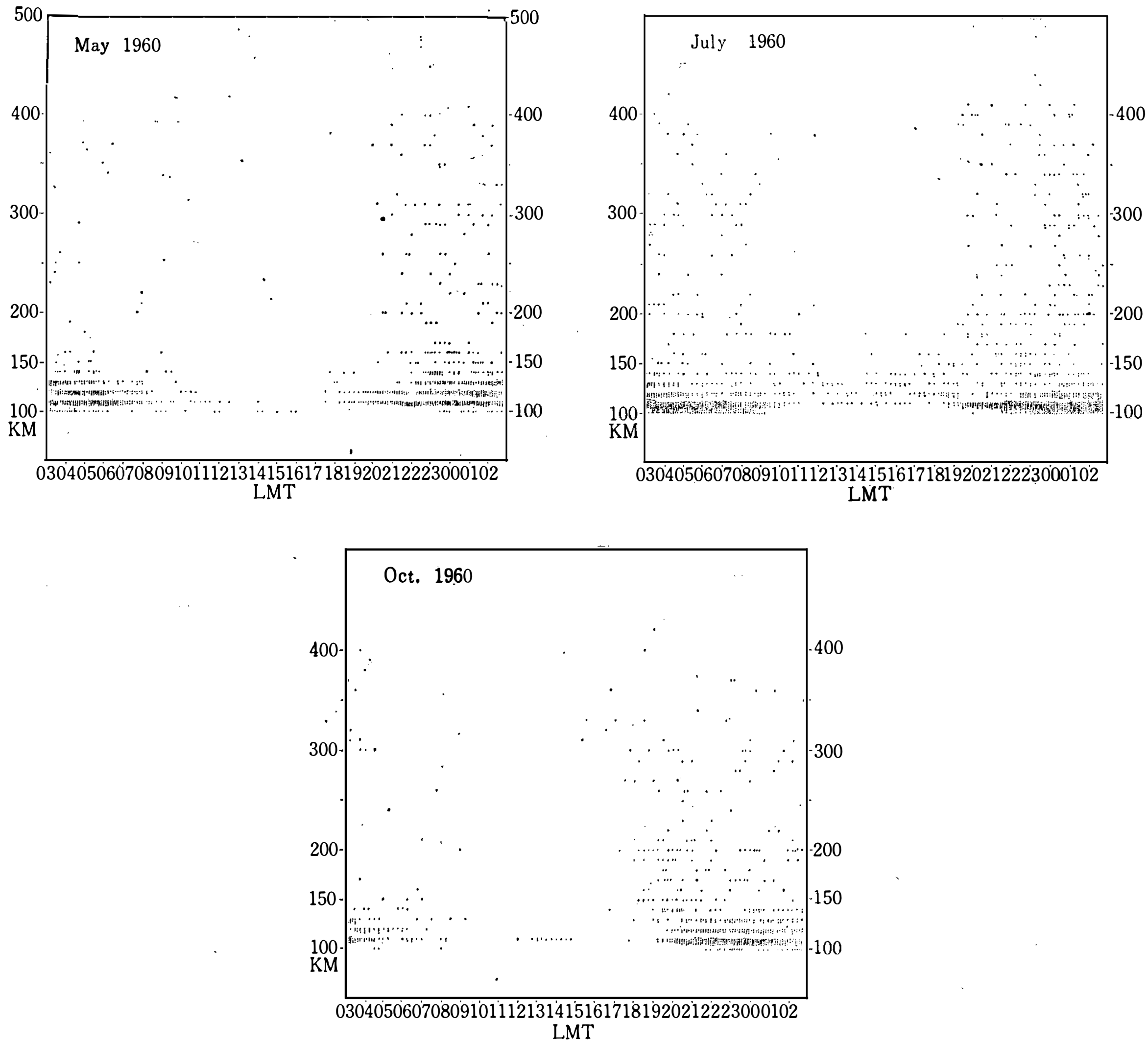

Fig. 7. Virtual heighs of E_s at Syowa Base.

frequency increases considerably in March, but decreases in April and May and increases again in June, showing a sudden decrease in and after October. November and December are the months of the fewest auroras. It seems that these have close relations to the sun's altitude in the magnetic latitude. The highest frequency of the auroral E_s is mostly about 4 Mc/s and is subject to little or no seasonal variations, while the width of scattering is far greater in winter and varies in large degree in this season. The width is usually about 50 km, but sometimes it amounts to several hundred kilometers.

As shown in Fig. 7, the height of the auroral E_s by season is nearly 110 km in the overwhelming majority of cases but some are different considerably. Among others, the height of more than 200 km is plotted mainly as the auroral F_s and it is difficult in many cases to discriminate the layer of a considerable height as it is likely to be confused with the oblique reflection and the multilayer reflection. The duration of its appearance is much shorter than that of the auroral E_s and it fades away in about an hour at the longest. By examination of the frequency of appearance classified into three grades of intensities in the diurnal variation throughout the year, it is found that all of the auroral E_s appear during the night only and the time of appearance is almost unchangeable between February and September. Such variations in the frequency of appearance show changes similar to the solar cycle of recurrence tendency, but the date of peak is almost in the middle of the cycle of time of solar disturbance. This means that because of the appearance of blackout of long duration always in the case of magnetic storms, etc., the auroral E_s is not recorded during that time. In other words, in about the middle of the solar cycle of disturbance the auroral E_s is the highest in intensity, especially being conspicuous between June and August in the winter.

5. Polar blackout

The blackout at Syowa Base comprises two types. One occurs suddenly for a short duration, while the other is due to magnetic storms, etc. and is of a longer duration. The former type is considered to be due to absorption in the lower region arising after the disappearance of an aurora and due to attenuation in the F region, etc. And the duration of appearance for both causes is as short as two or three hours. In the latter case, some would last as long as a weak and experience neither noise nor interference.

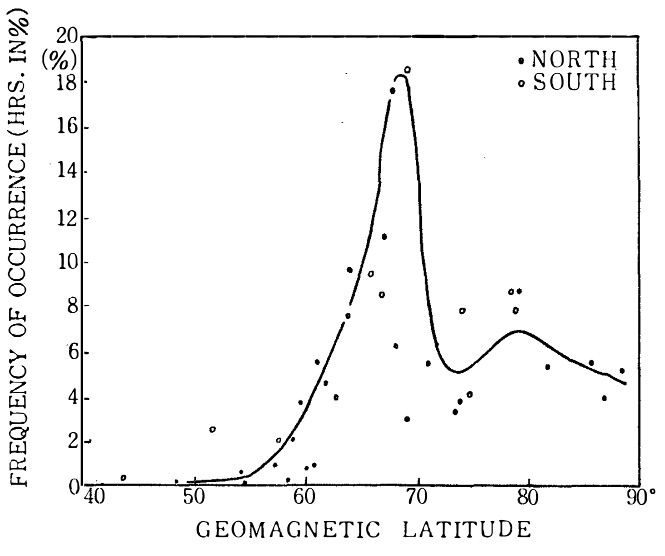

Fig. 8. Percentage of hourly frequency of occurrence of blackouts for the whole period plotted against the geomagnetic latitude.

As seen in Fig. 8, Syowa Base, being located in magnetic lat. −69.7° and magnetic long. 77.4°5, is within the region where the rate of appearance is the highest magnetic-latitudinally. Fig. 9 shows the frequency of appearance of blackout in each month of the year and there are seen considerably high rates throughout the year. Except in the summer of December to March, the monthly average is nearly 30%. In November in particular, it is higher generally, because there occurred blackout of long duration due to magnetic storms from the 12th till the 18th. It may be seen that the frequency of appearance has one peak between 0900 and 1000 hours (LT) throughout the year. This is a peculiar phenomenon in a polar region in the magnetic latitude, and during such hours the rate of appearance of blackout following the disappearance of auroras is high. During the winter season from May to August extraordinarily high peaks are seen at about 2000 to 2100 hours (LT), and this is a peculiar phenomenon of much interest to be noted only in the winter. There still remain the problems of the solar effect consequent on disturbance in winter, the incident angle of magnetic latitude, etc. that are subject to seasonal variation in the magnetic latitude. They are now under examination. The rate of appearance of blackout in the day is very low all through the year.

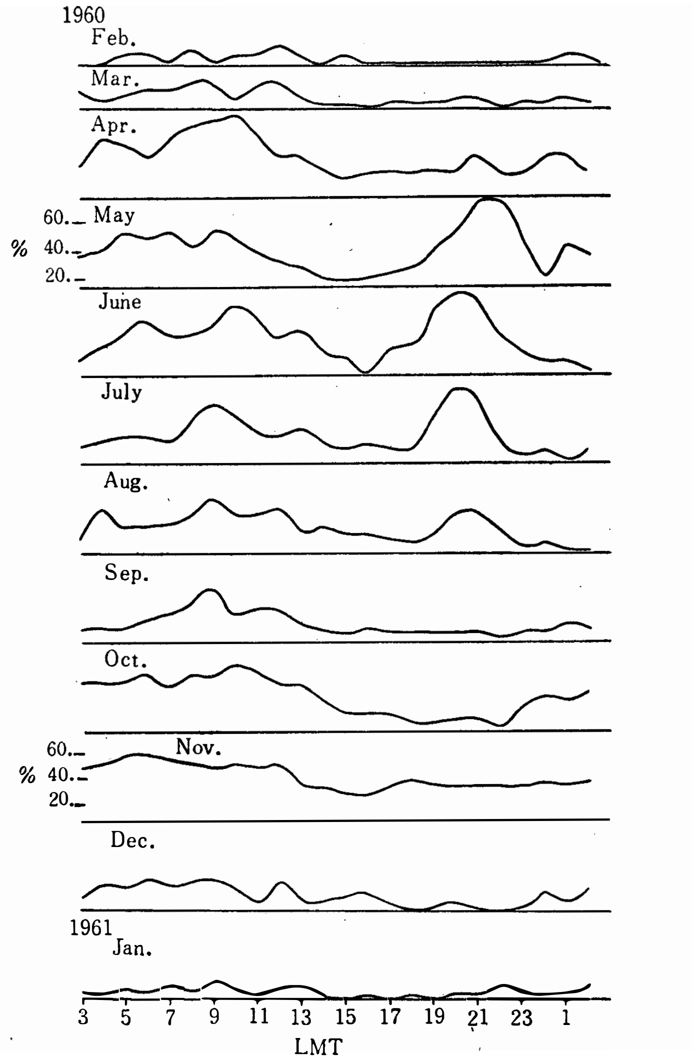

Fig. 9. Frequency of appearance of blackouts.

6. Conclusion

Examination is now over only partially on the ionospheric data obtained the whole year round, but the seasonal and diurnal variations in the auroral E_s at Syowa Base have been clarified. Also the frequency of appearance of blackout following the auroral E_s has received some light from this analysis. Further problems will come to solution by a comparative study with the data on auroras, terrestrial magnetism, etc. furnished by other departments of researches.

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