STATISTICAL CHARACTERISTICS OF NARROW-BANDED ELF EMISSIONS OBSERVED ON BOARD ISIS SATELLITE

Hiroaki SAITO[1], Takeo YOSHINO[1] and Natsuo SATO[2]

[1]*University of Electro-Communications, 5–1, Chofugaoka 1-chome, Chofu-shi, Tokyo 182*
[2]*National Institute of Polar Research, 9–10, Kaga 1-chome, Itabashi-ku, Tokyo 173*

Abstract: Occurrence distributions of narrow-banded ELF emissions over the southern polar region have been studied statistically from ISIS-1 and -2 VLF data which were received at Syowa Station ($L=6.1$) in Antarctica. It is found that emissions occurred mostly during the evening to the pre-midnight of 17–24 MLT and in the region of 65°–75° invariant latitude associated with V-shaped VLF hiss emissions. The emissions occurred during disturbed geomagnetic activities and the occurrence region shifted to lower latitude in association with geomagnetic activities. It is also found that the emissions have their occurrence maximum during the austral winter season from April to July. The emission frequencies are strongly depending on the height of the satellite position.

1. Introduction

Narrow-band ELF waves with the frequency band of 100–500 Hz have been seen in the electric field wave data from the polar orbital S3-3 satellite (TEMERIN and LYSAK, 1984). TEMERIN and LYSAK (1984) provided evidences that these waves were instead generated on auroral field lines in association with the auroral acceleration region, and that the frequency of the waves varies between the local hydrogen and the singly-charged helium gyrofrequencies.

Such narrow-banded ELF emissions as reported by TEMERIN and LYSAK (1984) are often observed at ISIS-1, -2 satellites whose data are received at Syowa Station in Antarctica ($L=6.1$). In this paper, emission frequency, magnetic latitude and local time occurrence distribution of narrow-banded ELF emissions over the southern polar region and their seasonal variations are studied using the ISIS-1 and -2 electric field data received at Syowa Station. We can define 235 events of narrow banded ELF waves among the 1122 orbital data received at Syowa Station from April 1976 to January 1984. Details of the ISIS-1, -2 satellite data description and data acquisition facilities at Syowa have been reported by BARRINGTON (1975) and YOSHINO *et al.* (1981). This paper may fill a vacancy of the works reported previously by TEMERIN and LYSAK (1984) for the statistical characteristics of narrow-banded ELF emissions.

2. Observation

A typical example of narrow-banded ELF waves observed on board ISIS-2 is shown in Fig. 1. The frequency-time spectra at the three different frequency ranges,

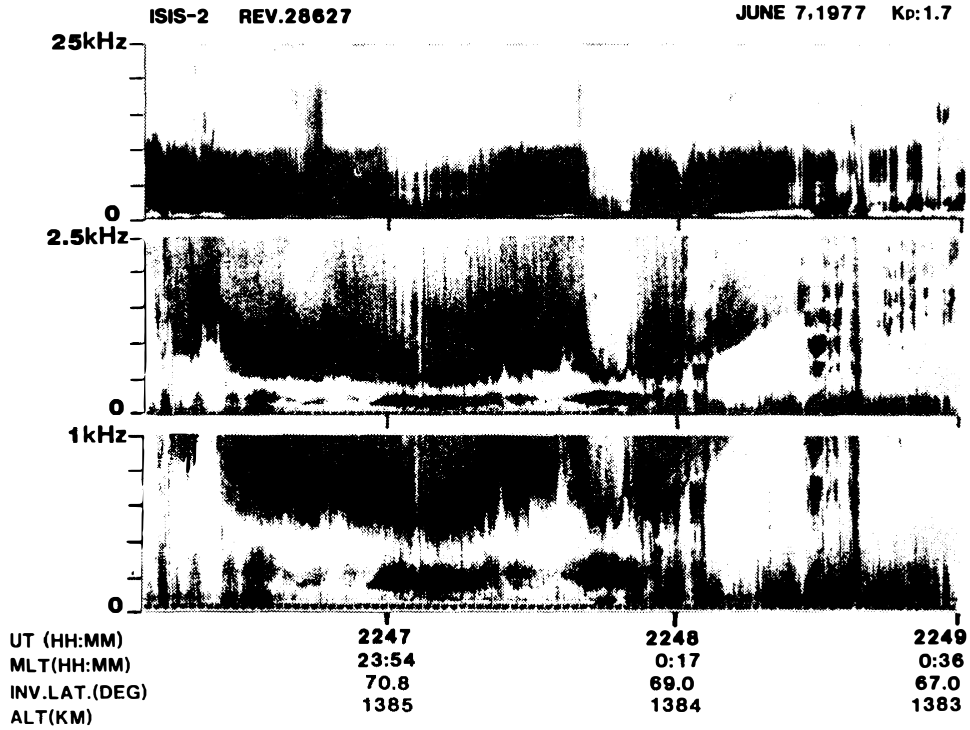

Fig. 1. Frequency-time spectra of typical narrow-banded ELF emissions at frequencies around 200 Hz during the time interval of 2246:20–2248:00 UT observed on board ISIS-2 on June 7, 1977.

0–25, 0–2.5 and 0–1 kHz are displayed in this figure. In this event the satellite moved in the midnight sector from high latitude to low latitude. The narrow-banded ELF emissions are evidently found at the frequency around 200 Hz during the time interval of 2246:20–2248:00 UT. It is noticeable that the narrow-banded emissions occurred during the time when V-shaped auroral VLF hiss frequency becomes minimum. It is also interesting that the duration of narrow-banded ELF emission is limited, less than one minute in this event. We selected such narrow-banded ELF wave events from thousands of *f-t* spectra observed at Syowa Station from 1976 to 1984 and carried out the statistical analysis.

Figure 2 shows the distribution of total passes of emission occurrences plotted on the polar map of invariant geomagnetic latitude and magnetic local time. It is evident that these emissions occur mostly in the region of averaged auroral oval and in the local time from evening to pre-midnight sectors. The ELF emissions are observed almost all during the local time interval, but higher emission occurrences appear in the region of 65°–75° during 16–24 MLT. These occurrence distributions are similar to those of auroral VLF hiss emissions rather than VLF saucer emissions in comparison with the results reported by YOSHINO *et al.* (1981). Figures 3a and 3b show the occurrence percentage of narrow-banded ELF emissions for the invariant geomagnetic latitude and magnetic local time, respectively. It is evident that the emissions have maximum occurrences in the auroral region from 65° to 75° geomagnetic latitudes and during evening sector of 16–17 MLT and pre-midnight sector of 21–24 MLT. Figure 4 illustrates the seasonal variations of the narrow-banded ELF emission

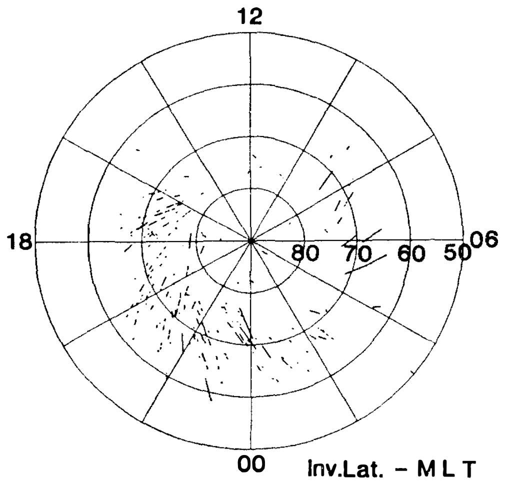

Fig. 2. The plots of all passes of ISIS satellites in which narrow-banded ELF emissions were observed on the polar map of invariant geomagnetic latitude and magnetic local time coordinate.

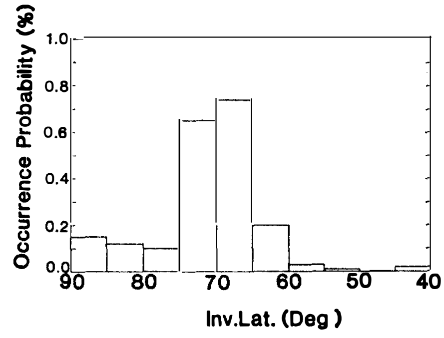

Fig. 3a. Occurrence probabilities of narrow-banded ELF emissions vs. invariant geomagnetic latitude.

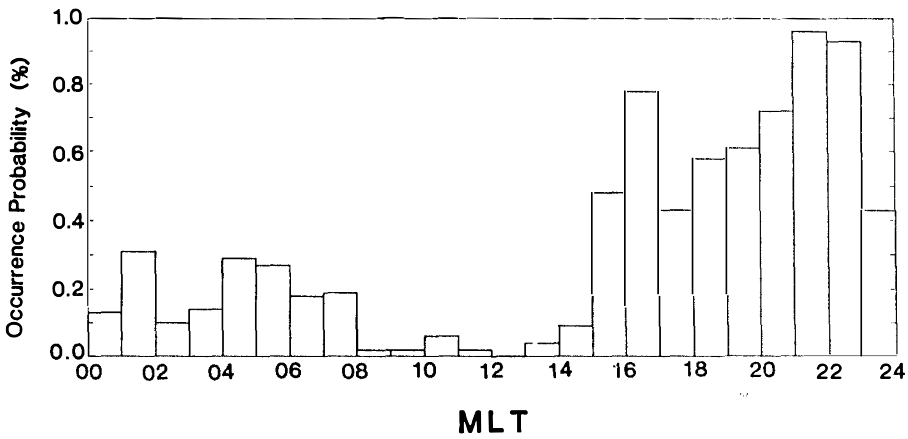

Fig. 3b. Diurnal variation of occurrence probabilities of narrow-banded ELF emissions.

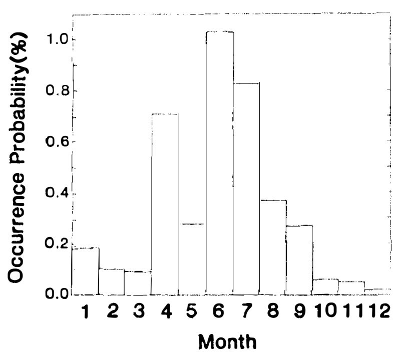

Fig. 4. Seasonal variation of occurrence probabilities of narrow-banded ELF emissions.

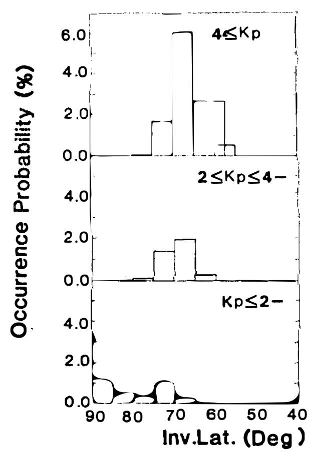

Fig. 5. Kp dependency of occurrence geomagnetic latitude of narrow-banded ELF emissions.

occurrences. It is very interesting that most of the emissions occur during the austral winter season from April to July.

We examined *Kp* dependence of the narrow-banded ELF emission occurrences. Figure 5 shows occurrence percentage of these emission regions at different geomagnetic activities of $Kp \leq 2_-$, $2 \leq Kp \leq 4_-$, and $Kp \geq 4$, respectively. It is obvious that emissions are more often observed during the most disturbed period ($Kp \geq 4$). The occurrence region shifts to lower latitudes in association with the increase of geomagnetic activity. These characteristics are almost the same as those of VLF hiss emissions reported by YOSHINO *et al.* (1981).

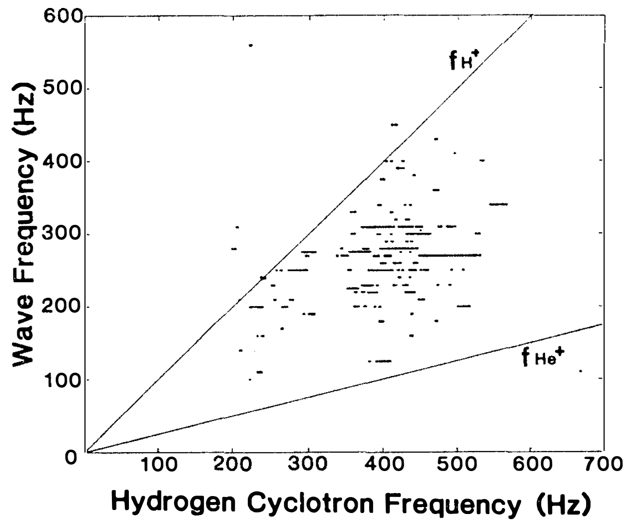

Fig. 6. The frequency of the observed narrow-banded ELF emission plotted vs. the local H^+ and He^+ cyclotron frequencies.

TEMERIN and LYSAK (1984) reported very clearly that narrow-banded ELF emissions are observed in the frequency range between the local hydrogen and helium cyclotron frequencies from the S3-3 satellite data. We also re-examined these characteristics by using the ISIS-1, -2 satellite data. Figure 6 shows the frequency dependence of the observed waves plotted on the local hydrogen frequency (f_{H^+}) and the single-charged helium gyrofrequency (f_{He^+}) deduced from the ISIS satellite altitude data. The characteristics of the frequency dependences are exactly the same as those reported by TEMERIN and LYSAK (1984).

3. Discussion

The work presented here is an extending work to cover the previous study reported by TEMERIN and LYSAK. The narrow-banded ELF emissions are interesting and important phenomena to study the acceleration mechanism of auroral particles because the emission may be generated by the auroral electron beams near or below the altitude at which it was accelerated. We discuss here the seasonal and diurnal variations of narrow-banded ELF emissions and their relation to the phenomena observed on the ground.

The statistical results of occurrence distributions of the emissions for geomagnetic latitude, local time and *Kp* dependences are easily understood because of their association with auroral VLF hiss emission and inverted V type electron fluxes, that is, the occurrence region shifts in association with the movement of auroral oval.

The strong seasonal dependence of emission occurrences shown in this report is very interesting and important to study the generation mechanism of the narrow-banded ELF emissions. Such a seasonal variation is probably explained by an increase of electron density and temperature in the topside ionosphere. It is suggested by TEMERIN and LYSAK (1984) that the growth rate for the electromagnetic ion cyclotron mode wave instability becomes lower as the temperature becomes higher and the ratio of the electron beam density to background density becomes lower. Such a condition is fulfilled in summer owing to an increase in the ionospheric scale height.

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