POLAR CUSP ELECTRON DURING QUIET AND DISTURBED PERIOD

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Abstract: On the basis of DMSP electron data obtained in both hemispheres, the characteristics of the dayside cusp electron precipitation are examined during quiet and disturbed geomagnetic activity periods. It is found that the latitudinal width of cusp region defined by precipitating electrons is very narrow (1–2°) during disturbed periods and very wide (∼5°) during quiet periods. It was also found that the cusp like precipitation could be seen even in the late evening sector in the quiet period suggesting the longitudinally extended cusp. On the other hand, the cusp was confined in the narrow local time during disturbed periods. All these features are seen nearly simultaneously in both hemispheres, showing a north-south hemispheric conjugacy.

1. Introduction

It is generally, accepted that the magnetos phere is separated into the closed and open field line regions. The boundary of these two regions separates the auroral oval and polar cap and is located at latitude higher than 75°. Through this boundary region, the solar wind particles are thought to be directly penetrate into the magnetosphere.

In an early work, OGUTI and MARUBASHI (1966) showed that an enhancement of electron density was seen around 75° MLAT near the noon sector by using ionospheric sounding observation. NISHIDA (1967) also showed that the electron number density peaked near the dayside region by using Alouette Satellite data. He considered that the enhancement of these background electron number density might be due to the precipitation of solar wind particles.

The first direct observations of the solar wind plasma in the dayside mangetosphere was carried out by Isis 1 and Imp 5 by HEIKKILA and WINNINGHAM (1971) and FRANK (1971). From the differential electron spectra observed in the low altitude magnetosphere and the magnetosheath, they showed that the magnetosheath particles precipitated directly to the dayside ionosphere through the geomagnetically neutral region on the dayside magnetopause. They called these neutral region the cleft and/or cusp.

DOERING *et al.* (1976) observed the dayside low energy electron (1–500 eV) in detail and found that the peak energy of cusp electrons was seen near 50 eV. Recently CANDIDI and MENG (1984) also examined the characteristics of cusp electron by using low-altitude polar orbits DMSP satellite data and showed that the similar low average energy differential spectra were seen in both hemispheres almost simultaneously. On the other hand, the dayside visual aurora related to these electron precipitations was examined by HEIKKILA *et al.* (1972) by the aircraft observations. They showed that the intensity of 6300 Å line increased remarkably near the region where the intensity of 4278 Å line decreased. They also found that the intensity of H_β line increased in association with the increasing of 6300 Å line. SHEPHERD (1979) examined the global dayside aurora by using Isis satellite data. He showed that the enhancement of 6300 Å line was clearly seen near the dayside auroral oval region.

From the ground meridian scanning photometer observation at Ny-Alesund, HENRIKSEN *et al.* (1978) showed that the intensity of the 6300 Å line was always larger than that of the 5577 Å line. Furthermore, DANDEKAR and PIKE (1978) and MENG (1981) found by using DMSP auroral photographs that there is the midday auroral gap along the auroral oval by using DMSP auroral photographs. They suggested that the precipitating electron energy near the dayside cusp was insufficient to excite bright auroras which are detectable by the DMSP auroral imager. From these various kind of particle and aurora observations, it was become clear that the precipitating electron energy in the dayside cusp region (a peak energy is less than 100 eV) is smaller than that of auroral particles (a peak energy is a few keV) in the night sector by about one orders.

The movement of the cusp has been studied by several workers. They showed that the locations of the polar cusp depends on the IMF polarity and also on the geomagnetic activity. BURCH (1973) and KAMIDE *et al.* (1976) and MENG (1983) examined the latitudinal movement of the cusp and their relationships to the IMF *Bz*. According to their results, the cusp boundary shifts equatorward as the magnitude of negative IMF *Bz* values increase. However, the shift of the cusp could not be clearly recognized for positive *Bz*.

Since the relationships between the magnitude of the IMF *Bz* and the cusp location is not well known during the quiet (northward IMF) period. We examine this point in this paper.

2. Characteristics of Cusp Precipitation and Aurora

The location of the cusp electron precipitation region and its characteristics during the quiet period are quite different from those during disturbed period. On the basis of DMSP electron data, the cusp precipitation observed in both hemispheres during quiet and disturbed periods are examined.

2.1. *The characteristics of the cusp precipitation during quiet periods*

In order to compare the cusp precipitation in both hemispheres during quiet period, it is important to examine the electron data obtained near the equinox season because the tilt angle between solar wind and the earth dipole axis in both hemispheres is small in this period and thus the geometric condition in both hemisphere is similar. We selected the data obtained near the equinox as shown in Fig. 1a. It shows the *AE* index and the satellite polar passes in both hemispheres. From 05 to 11 UT on September 22, 1979, hourly average values of *AE* index are less than 50 nT and IMF

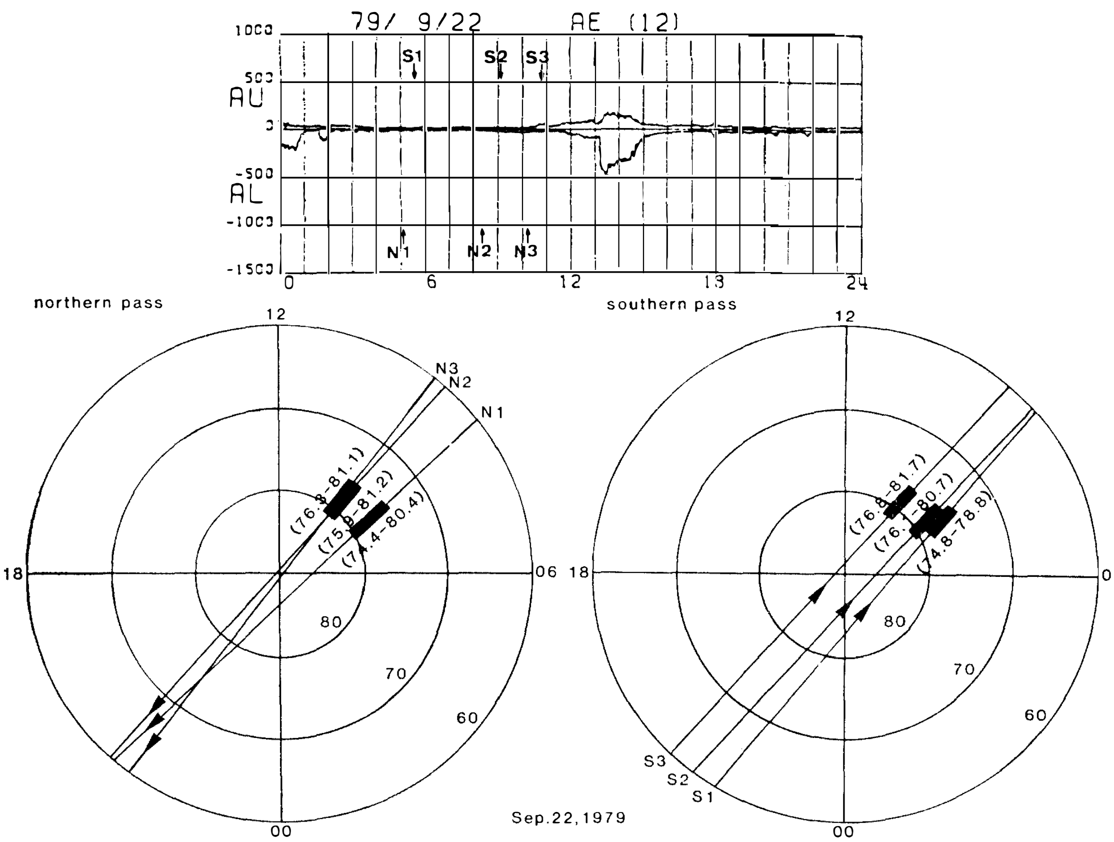

Fig. 1a. Top panel shows AE indices. The arrows of S1, S2, S3 and N1, N2, N3 in the top panel correspond to electron observation period in the southern and northern hemisphere, respectively. It is noticed that these observation periods are very quiet. Bottom two panels show the northern and southern polar passes. The black hatched area indicate the cusp region estimated from DMSP electron data.

Bz was northward, ranging from 2 to 6 nT (Interplanetary Medium Data Book, Supplement 2, 1983). The arrows in the top panel shows the satellite passes in both hemispheres. In the bottom two panels, the thin line show the satellite orbit and the black hatched shadow region indicates the cusp region estimated from DMSP electron data as shown in Figs. 2a and 2b. The cusp precipitation region are roughly seen from 74° to 81° in the northern hemisphere and 75° to 82° in the southern hemisphere. In order to examine the interplanetary magnetic field condition in this event, IMF data obtained by the ISEE-3 satellite are shown in Fig. 1b. It is noted that ISEE-3 satellite was located at about 250 R_E from earth. Thus, there is about one hour time lag in comparing ISEE-3 solar wind data and DMSP electron data. Figure 1b shows that IMF *Bz* value is positive (northward) during the interval from 0000 to 0930 UT, which correspond to the period from 0100 to 1030 UT on the ground. Therefore, it is concluded that the examination period shown in Fig. 1a corresponds to the northward IMF period. The electron data observed in the northern and southern polar passes are shown in Figs. 2a and 2b, respectively. In these figures each panel contains the electron total number flux, energy flux and average energy. In Fig. 2a, it can be clearly recognized that there are homogeneous, low average energy and high

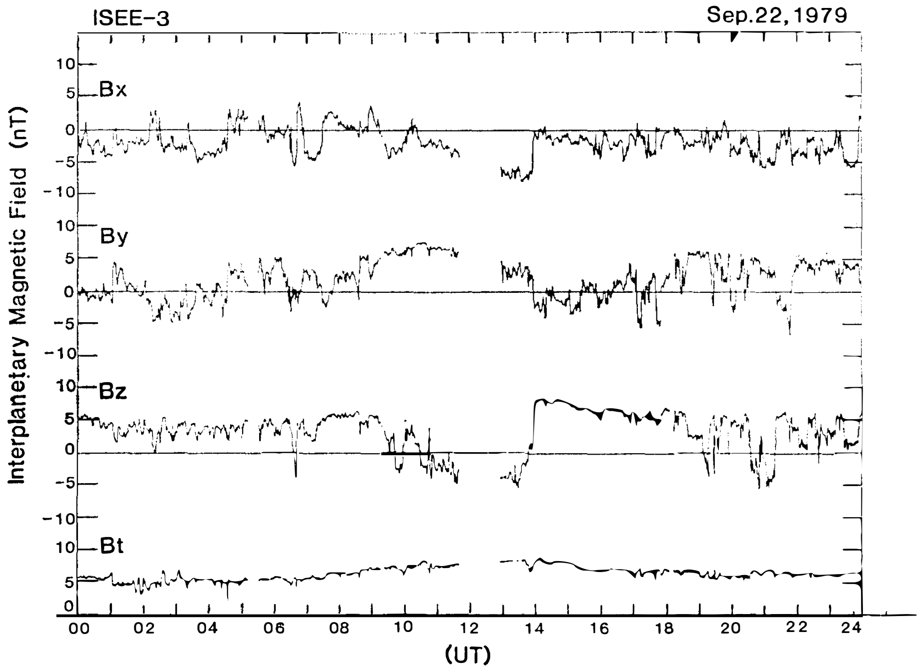

Fig. 1b. Interplanetary magnetic field (IMF) data observed by ISEE-3 satellite.

flux precipitations, which we define here as the cusp electron precipitations, near the noon sector in the northern polar passes. They are seen from 74.4° to 80.4° in the top panel, 75.9° to 81.2° in the middle panel and 76.3° to 81.1° in the bottom panel. The characteıistics of these cusp electron precipitation identified here are similar to the cusp precipitation determined by CANDIDI and MENG (1984). It is also seen that there are regions of more irregular average energy electron precipitations on the higher latitude side of these cusp precipitation region. Especially, these irregular low energy precipitation regions extend to an extremely high latitude (>85°) during the geomagnetically quiet, northward IMF period as reported by MAKITA and MENG (1984). Similar electron precipitations are also recognized in the southern hemisphere as shown in Fig. 2b. The format in this figure is the same as that in Fig. 2a. In these three polar passes, the region of homogeneous, low average energy and high flux electron precipitation are also seen near the noon sector. These cusp precipitation regions are seen from 74.8° to 78.8° in the top panel, 76.1° to 80.7° in the middle panel and 76.8° to 81.7° in the bottom panel. The irregular high flux electron precipitation region are seen in the higher latitude side of these cusp precipitation. It should be noted that the similar homogeneous low average energy and high flux precipitation are also recognized in the night side region (21 MLT) in the bottom panel of Fig. 2b. The origin of these low average energy and high flux electron precipitations in the night side is not clearly understood at the present time. However, this kind of electron precipitation is frequently observed during extremely quiet periods.

2.2. The characteristics of cusp precipitations during disturbed period

Generally, the location of the cusp moves to the equatorward as the magnetic activity increases. The electron data obtained in the magnetically disturbed period are selected for both hemispheres near the equinoctial season. Figure 3a shows *AE*

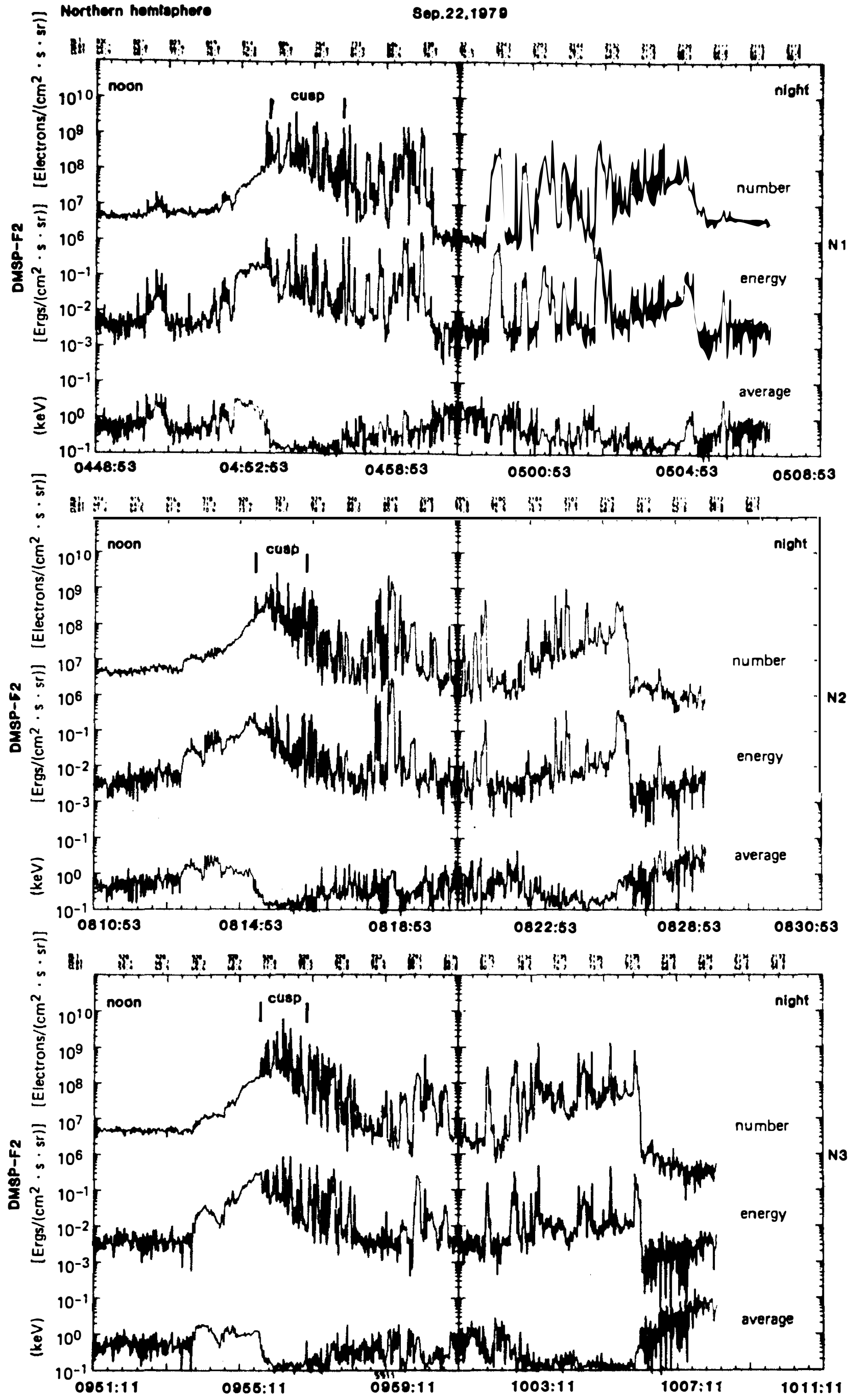

Fig. 2a. Top (N1), middle (N2) and bottom (N3) panels show electron precipitation data obtained by DMSP-F2 satellite in the northern hemisphere. These three panels correspond to three polar passes shown in Fig. 1. Each panel shows electron number flux, energy flux and average energy, respectively. It is noticed that the average electron energy is extremely low in the cusp region.

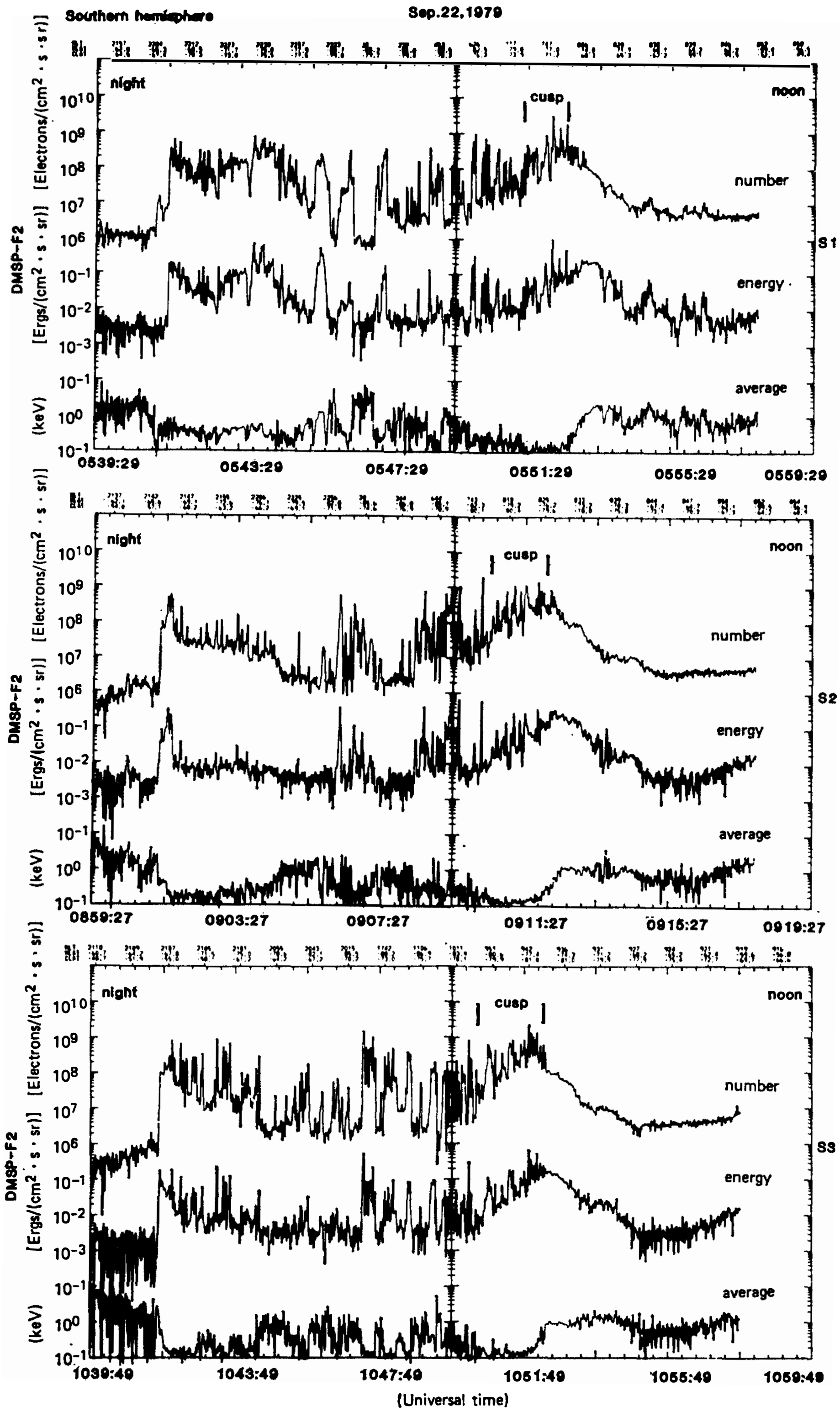

Fig. 2b. Top (S1), middle (S2) and bottom (S3) panels show electron precipitation data obtained by DMSP-F2 satellite in the southern hemisphere. The format in this figure is the same as that in Fig. 2a.

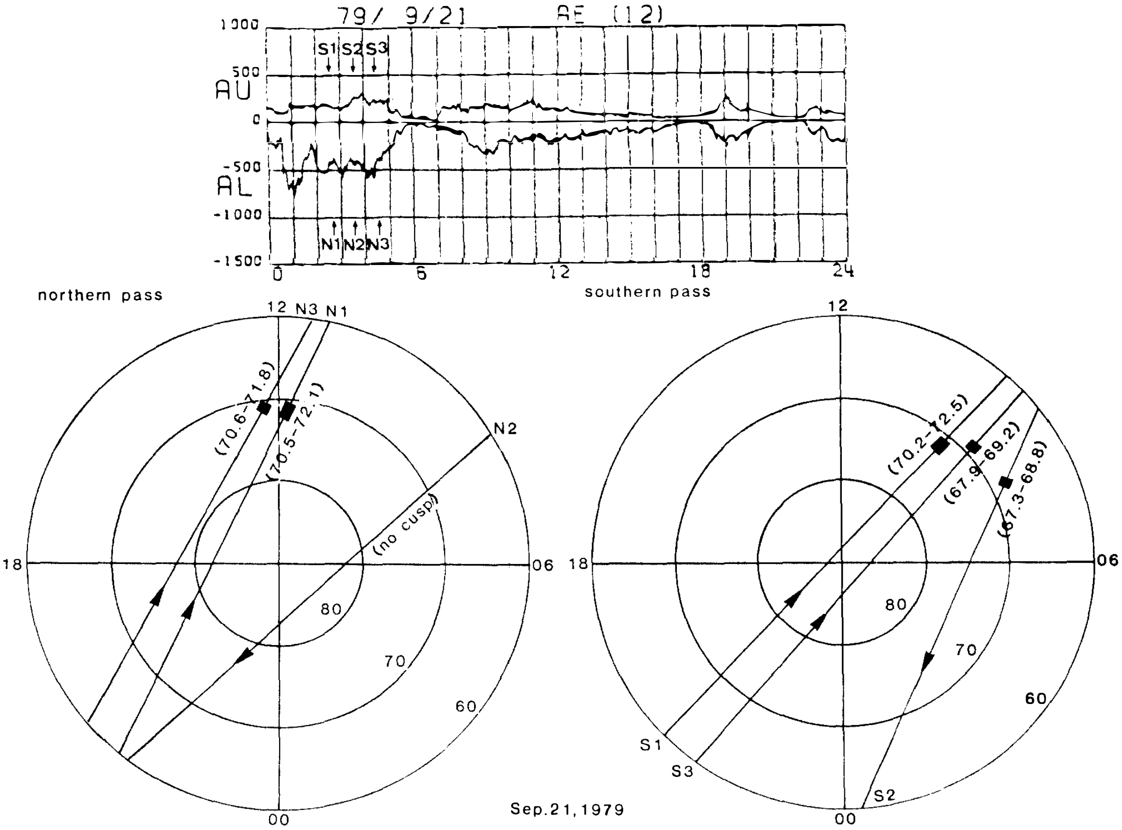

Fig. 3a. Top panel shows AE index and bottom two panels show the northern and the southern polar passes. The format in this figure is the same as that in Fig. 1a. It is noticed that these observation period is very disturbed.

indices and the northern and southern polar passes. From 0200 to 0500 UT on September 21, 1979, the hourly average value of AE index is larger than 500 nT. In the top panel, the arrows show the electron observation period in both hemispheres. In the bottom two panels, the thin line and the black hatched region indicate the satellite orbit and the cusp precipitation region, respectively. From these two bottom panels, it is recognized that the cusp precipitation regions are seen in the lower latitude side (*i.e.*, 70°–72° in the northern hemisphere and 68°–72° in the southern hemisphere) than that during quiet periods. The DMSP electron precipitation data observed during this period are illustrated in Figs. 4a and 4b. The corresponding IMF data obtained by ISEE-3 satellite are shown in Fig. 3b. They show that the IMF was directed southward during the period from 0000 to 0330 UT on September 21, 1979, which may correspond to the period from 0100 to 0430 UT on the ground. Figure 4a shows the electron total flux, energy flux and average energy obtained in the northern hemisphere. In the top and the bottom panels, the homogeneous low average energy and high flux precipitation region are seen near the noon. They are located at the magnetic latitude from 70.5° to 72.1° in the top panel and 70.6° to 71.8° in the bottom panel. It can be seen that the cusp precipitations is not clearly recognized in the middle panel data. In this interval, the DMSP satellite traversed from the morning sector (08 MLT) to the late evening sector (22 MLT) and the lack of cusp

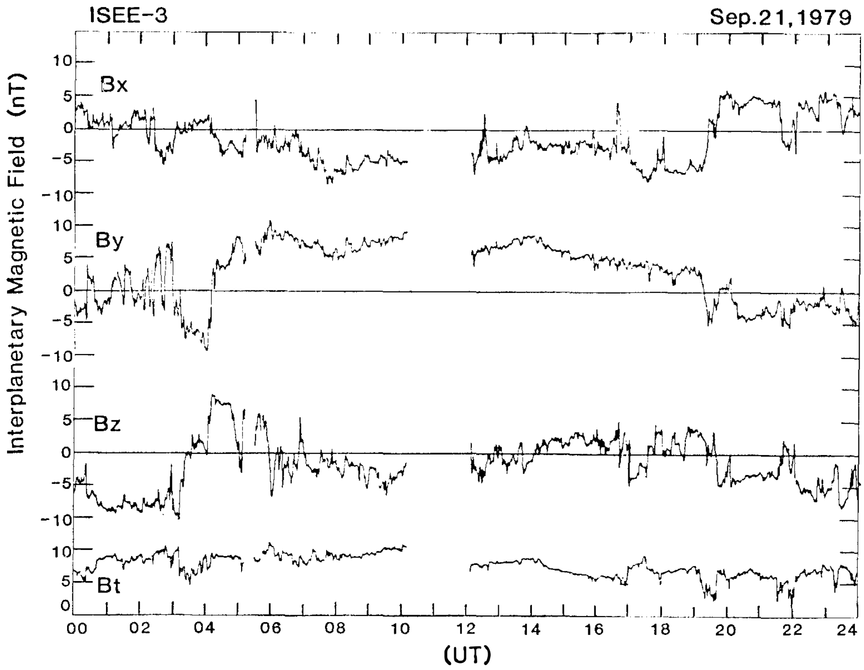

Fig. 3b. Interplanetary magnetic field (IMF) data observed by ISEE-3 satellite.

precipitation may indicate that the cusp region did not extend to the morning sector in this period. In the southern polar passes as shown in Fig. 4b, the cusp regions can be recognized near 08 MLT in each three panels. They are located at the magnetic latitude from 70.2° to 72.5° in the top panel, 67.3° to 68.8° in the middle panel and 67.9° to 69.2° in the bottom panel. We note that the cusp region is recognized near the late morning sector (~08 MLT) in the southern hemisphere in this period. This fact suggests that the cusp region extends to the late morning sector in the southern hemisphere, although it did not extend to the same local time sector in the northern hemisphere.

From the examination of Figs. 4a and 4b, it is clear that the width of the cusp region during disturbed periods is very narrow (1°–2°) as compared to the one during the quiet period (~5°). It also indicates that the cusp like low average electron precipitation cannot be seen in the night side during disturbed periods.

3. Summary and Discussion

The characteristics of the cusp precipitation was examined during quiet (northward IMF) and the disturbed (southward IMF) periods. It is found that the cusp precipitation region shows fairly good conjugacy between two hemispheres. Namely, the cusp region is located at about 75° to 81° during quiet periods. On the other hand, during disturbed periods, its region is confined at about 70° to 72° in both hemispheres. It is our new finding that the latitudinal width of the cusp region during quiet periods is about 5°–6°, which is about a few times larger than that during disturbed periods (1°–2°).

Furthermore, our data suggest that the cusp-like precipitation extends longitudinally to the late evening sector during quiet periods. However, the cusp is con-

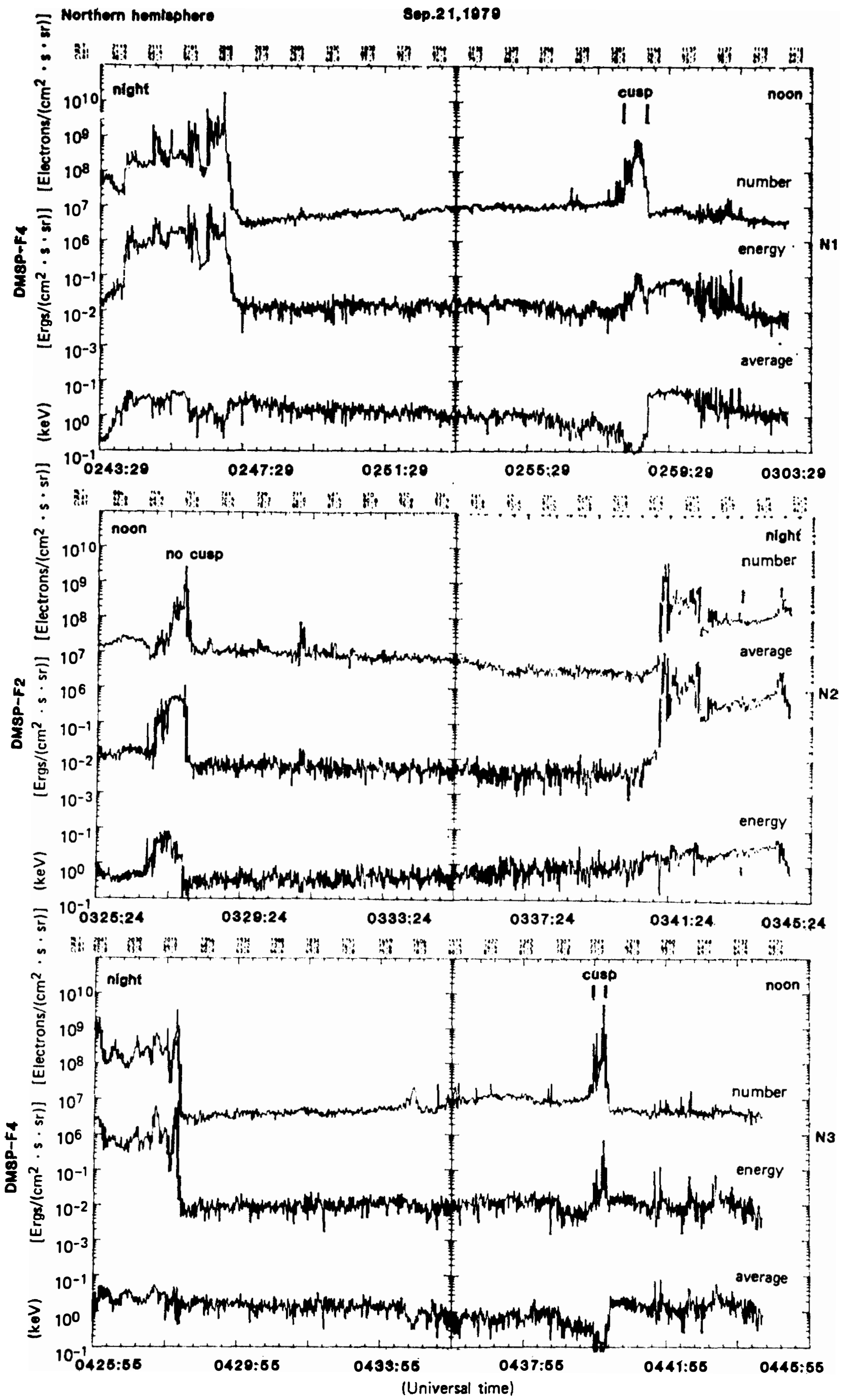

Fig. 4a. *Top (N1), middle (N2) and bottom (N3) panels show electron precipitation data obtained by DMSP-F2 and -F4 satellites in the northern hemisphere. These polar passes data are shown in Fig. 3a.*

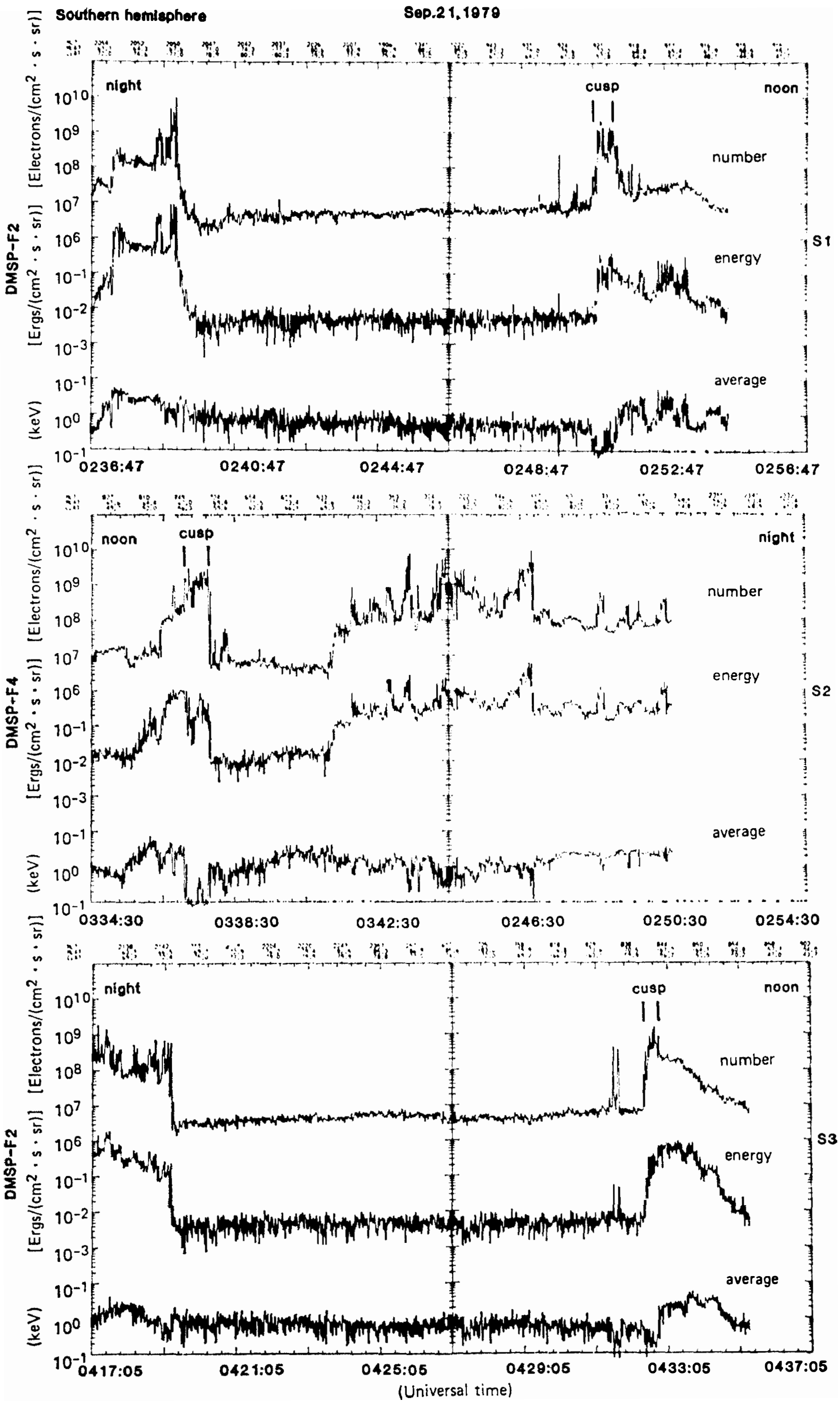

Fig. 4b. Top (S1), middle (S2) and bottom (S3) panels show electron precipitation data obtained by DMSP-F2 and -4 satellites in the southern hemisphere. The format in this figure is the same as that in Fig. 4a.

fined near the narrow local time sector during disturbed periods. It may be interest to see whether or not these low energy electron precipitations near the night side have the same origin as that of the dayside cusp precipitation.

Our study suggests that the dayside magnetospheric structure is quite different between quiet geomagnetic activity periods and disturbed periods. This result may be suggested that the dayside last closed geomagnetic field lines move to the higher latitude and thus the magnetic neutral region (cleft or cusp) also moves to the higher latitude during the quiet northward IMF period. In this period, the latitudinal width of neutral region may expand.

Although our examinations are not sufficient to say a certain conclusion, our result suggests that the magnetically neutral region (cusp) extends in the morning and evening directions and the magnetosheath particles may be precipitated to the ionosphere through these longitudinally extended neutral region during the quiet northward IMF period.

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