

SOME FEATURES OF THE ENERGETIC ELECTRON PRECIPITATION IN THE EVENING SECTOR

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Abstract. Specific type of the energetic electron precipitation was found in the data obtained from the NOAA satellites. The statistical characteristics of this type of precipitation as well as the results of the comparison with other measurements are described.

1. Introduction

Localized energetic electron precipitation from the inner magnetosphere was the subject of many studies in the past (see, for example, papers by Vampola [1971], Thorne and Andreoli [1980], Imhof et al. [1986] and references herein). Thorne and Kennel [1971] suggested that in the evening and night sectors the precipitation of relativistic electrons from the radiation belt is related to the electromagnetic ion cyclotron waves. These waves are generated due to overlapping of the ring current protons and plasmasphere occurring during the main phase of the magnetic storm. But, as it was shown by Imhof et al. [1986], the localized precipitation of electrons from the inner part of the radiation belt correlates with the proton precipitation only in 31% of the observed events. Thus, the mechanism of precipitation seems to be unknown yet, and more investigations are required.

In this paper we consider a specific phenomenon that is found in the data of the energetic particle measurements obtained from the low altitude NOAA satellites. The phenomenon is the sharp gradient of the trapped energetic (> 30 keV) electron flux which is observed in the vicinity of maximal intensity of the trapped population. The energetic electron precipitation structure is also observed in close relation to this sharp gradient. We studied the morphological characteristics of these particle precipitation structures as well as their relation to the magnetic activity. In addition we considered the relationship between the precipitation structures and cold plasma gradients that mark the plasmasphere or detached plasmaspheric plasma boundary. We conclude that the considered precipitation features might be a result of interaction of energetic electrons drifting around the Earth with the cyclotron waves in the vicinity of the cold plasma gradient.

2. Observational results

The NOAA spacecraft are the low-altitude (850 km) satellites with near-circular orbits. The satellites are equipped with the MEPED instrument for measurements of the particles with energy > 30 keV. The instrument has two detectors oriented (when the satellite is at $L > 3$) one along and another perpendicularly to the magnetic field. Thus it can measure both trapped (at the altitude of the satellite) and precipitating particles. Looking through the MEPED instrument data we noted a phenomenon with example is shown in Fig.1. It is a sharp gradient in the trapped energetic electron flux which is observed near the latitude of the maximal trapped population intensity. The sharp gradient of the trapped electron flux is characterized by several times increase of the flux when the latitude increases by 0.1 - 0.2 degrees.

Because of the sharpness of the flux variation we will further call this feature a "cliff". Simultaneously with the "cliff" the burst-like enhancement of the precipitation flux is seen in the localized latitudinal region. Below we are presenting some statistical characteristics of these features. To do the statistics we used the NOAA data obtained from the time intervals of 01 - 10 August 1979 (TIROS-N), 11 - 31 August 1979 (TIROS-N, NOAA-6), 01 - 10 May 1980 (NOAA-6), 21 - 30 November 1981 (NOAA-6, NOAA-7). In all, 114 events have been considered. It has been found that:

- 1) H_{cliff} proportional to the maximal J_{tr} .
- 2) The relation of intensities of the precipitating and trapped flux is less than 1; in general it is less than 0.4 although a tendency of growth is noted when the maximal J_{tr} increases.
- 3) 92 events (80.7%) were observed at 16 – 22 MLT.
- 4) The “cliff” and related precipitation bursts are observed mainly at the corrected latitude $60 \pm 3^\circ$. The latitude of the “cliff” exhibits the tendency to be smaller for latest MLTs. This tendency is confirmed by the simultaneous observations done by two satellites situated on different MLTs.
- 5) The “cliff” events are observed equatorward of the low-latitudinal edge of the proton precipitation.
- 6) 93 events (81.6%) are observed during magnetic storms. The rest falls into the intervals after small magnetic disturbances. More detailed consideration of the relationship between the observations of the “cliff” and magnetic disturbances shows that, in fact, the events are observed during the storm recovery phase.

To illustrate this fact the Dst index is plotted in Fig. 2 for two prolonged intervals covering four magnetic storms. The black squares mark the times when the “cliff” events were detected.

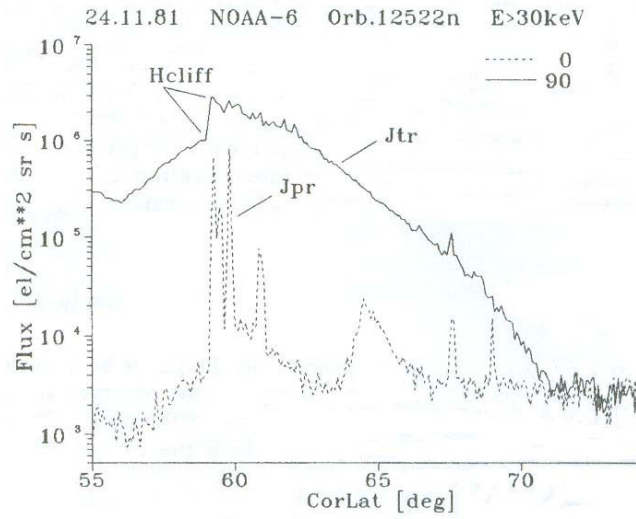


Fig. 1

3. Comparison with other satellite data

As far as we know, the “cliff”-like phenomenon has not been described in previous studies of the energetic electron precipitation from the inner magnetosphere. Nevertheless we consider this feature as the important characteristic of deformation of the pitch-angle distribution function in the course of the resonance interaction of cyclotron waves and energetic particles [Traktengerts *et al.*, 1996]. The presence of cold plasma gradient is required for such interaction. To verify the existence of the cold plasma gradient we carried out some additional comparisons. Firstly, we compared the averaged L -value of the “cliffs” with that of the sharp cold plasma gradients found by Carpenter and Anderson [1992] from the ISEE satellite data. The result of comparison shows very good coincidence of the location of these phenomena, especially in the evening sector. Then, we compared two particular cases of the “cliff” observations with the data obtained onboard the DE-1 and Auteol-3 satellites. Both these events occurred on 24 November 1981. In the case of the DE-1

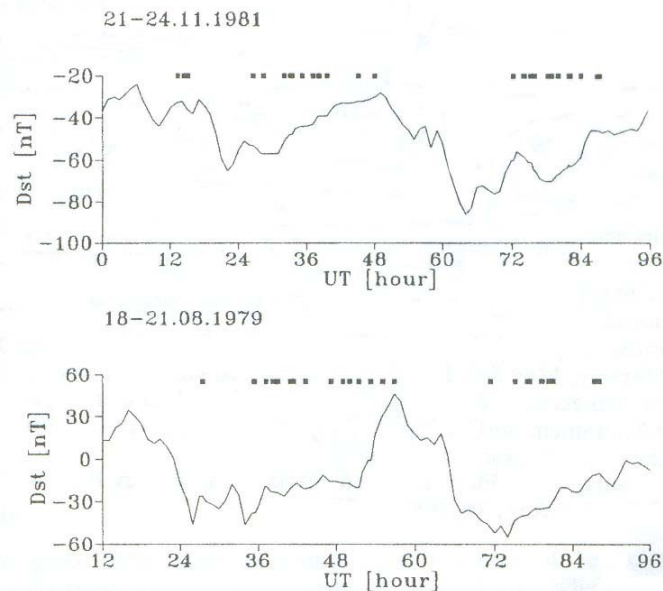


Fig. 2

we used the measurements of the low-energy (< 50 eV) ions to determine the location of the cold plasma gradient [Horwitz et al., 1990]. The DE-1 satellite was in the sector of 18 – 19 MLT. The NOAA-6 satellite measurements during two successive passes in the same MLT sector located the “cliff” very close to the latitude of the cold plasma density gradient. Another event of 24 November which occurred also in the 18 MLT sector showed good coincidence of the “cliff” latitude determined from the NOAA-6 data with the location of sharp change of the plasma frequency determined from the Aureol-3 measurements. Such behaviour of the plasma frequency means the presence of the cold plasma gradient. In the same region the Aureol-3 satellite recorder the intensification of the ELF waves in the range 100 - 1000 Hz. This fact confirms the favourable conditions for generation of the waves in the region.

4. Discussion

It seems that mechanism proposed in the paper by Thorne and Kennel [1971] (bellow we are referring to this paper as the paper TK) can not explain the observed features of the “cliff”. Indeed, the mechanism should work preferably during the main phase of the magnetic storm when the injected protons penetrate into the region occupied by the cold plasmaspheric plasma (see, Fig. 1 in the paper TK). Also, as it has been noted in the Introduction, the electron precipitation has to be accompanied by that of protons. These predictions of the paper TK disagree with our findings (see, features 5 and 6 listed above). These contradictions disappear if we apply the mechanism of the electron cyclotron interaction developed by Trakhtengerts et al. [1996] and keep in mind the plasmopause structure which is expected [e.g. Kurita and Hayakawa, 1985] and observed [Carpenter, 1993] during the magnetic storm recovery phase. The plasmopause itself contracts and the “tongue” of the cold plasma detaches from the plasmasphere and extends from the night-evening sector to the day sector (see Fig. 1 in the paper by Trakhtengerts et al. [1996]). Energetic electrons drifting to the East will meet the “tongue” of the cold plasma, and precipitation due to a cyclotron wave-particle interaction mechanism can produce the features discussed above.

Acknowledgments. This work was supported by the INTAS grant No. 94-2753. The NOAA satellite data were obtained through WDC-A.

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