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ELECTRIC FIELDS AT MIDDLE LATITUDES DURING THE GREAT MAGNETIC STORM IN MARCH 1989 —OBSERVATIONAL RESULTS BY EXOS-D SATELLITE— (EXTENDED ABSTRACT)

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1. Introduction

We study spatial and temporal variations of the intense electric field which was observed by the double probe system (HAYAKAWA *et al.*, 1990) onboard the EXOS-D satellite (OYA and TSURUDA, 1990) in middle latitudes during the great magnetic storm of March 13–14, 1989.

2. Magnetic Activity

The magnetic storm started at 0128 UT on March 13. Figure 1 shows plots of the hourly equatorial Dst values during March 13 and 14, 1989, provided by the World Data Center C2 (WDC–C2) for Geomagnetism, Kyoto University (KAMEI *et al.*, 1989). Two storm sudden commencement (SSC) events at 0128 UT and 0747

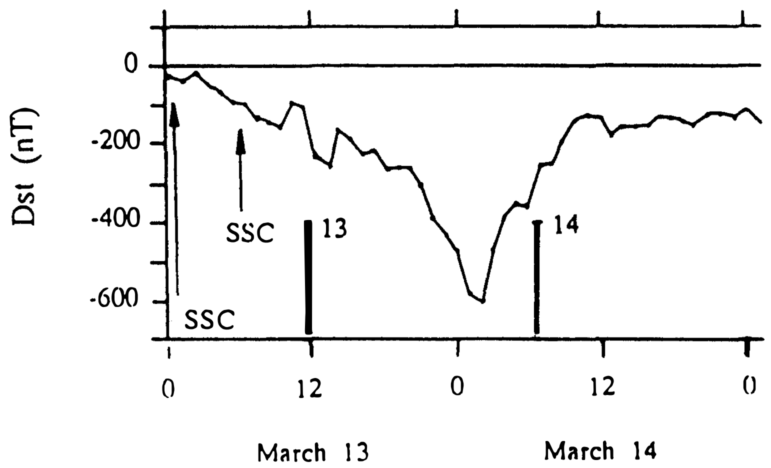

Fig. 1. Records of the Dst index on March 13 and 14, 1989. The bars show the durations of the electric field observations by the EXOS-D satellite.

UT on March 13 are denoted by arrows. The main phase of the storm continued until around 0130 UT of March 14, and the recovery phase followed on March 14.

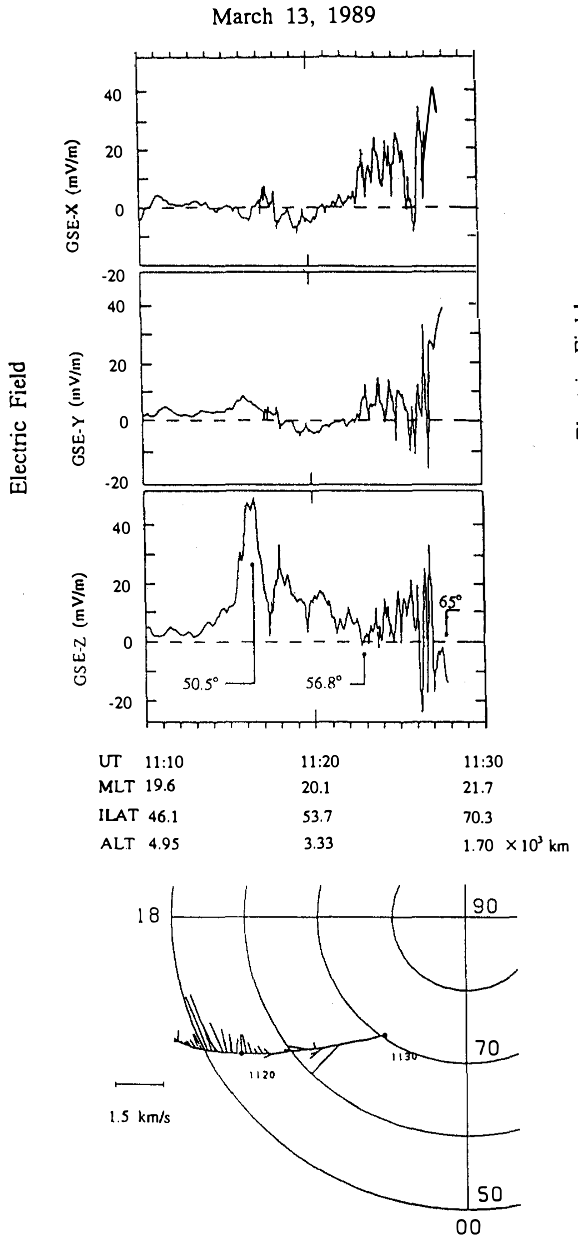

Fig. 2.

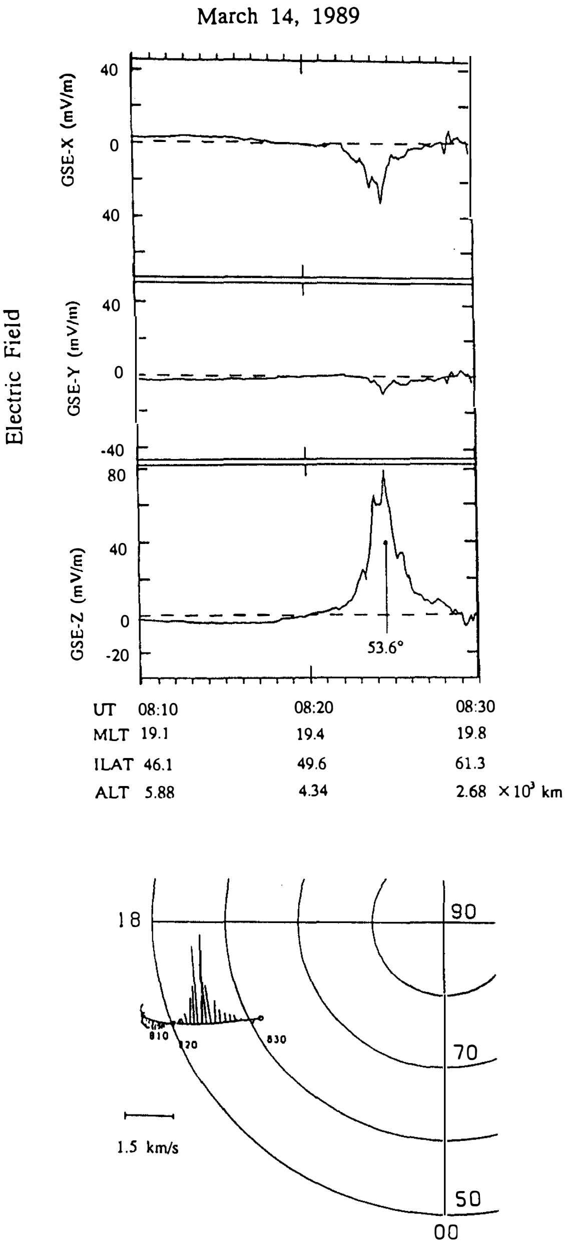

Fig. 3.

Fig. 2. The upper three panels show the GSE-X, -Y, and -Z components of the electric field in the GSE coordinate system along the satellite orbit during the time 1110–1130 UT on March 13, 1989. The lowest panel shows the vectors of plasma convection projected to an altitude of 120 km in the MLT-Invariant latitude coordinate system.

Fig. 3. Same as Fig. 2 but for 0810–0830 UT on March 14, 1989.

3. Electric Fields during the Main Phase

The enhanced electric fields are detected on the pass in the northern hemisphere on March 13, the time window of which is denoted by the bar numbered 13 in Fig. 1.

Figure 2 shows the electric field data and the corresponding convection on March 13. Three panels from the top of Fig. 2 indicate the GSE-X, -Y, and -Z components of the electric field, respectively, during the period 1110–1128 UT as functions of universal time (UT), geomagnetic local time (MLT), invariant latitude (ILAT), and altitude (ALT), while the lowest panel indicates the plasma convection vectors projected to a reference altitude of 120 km along the pass, calculated from the three electric field components and the magnetic field components observed by the magnetic field experiment onboard the EXOS-D (Fukunishi *et al.*, 1990). The time separation of the neighboring vectors is 32 s. As the satellite moved from lower latitudes to higher latitudes, it was observed that the GSE-Z component increased sharply from the background level around 48° ILAT and reached a peak value of 48 mV/m around 1116:30 UT (50.5° ILAT, 3900 km ALT). Both GSE-X and -Y components are about one order of magnitude smaller than the GSE-Z component when it is maximum. This enhanced positive GSE-Z component, with weak GSE-X and -Y components, indicates westward (sunward) convection of the magnetospheric plasma and the convection velocity is estimated as 5.7 km/s at 3900 km ALT. The electric field intensity and the convection velocity at 3900 km ALT are equivalent to 100 mV/m and 1.8 km/s respectively when projected to the altitude of 120 km as shown in the lowest panel of Fig. 2.

At higher latitudes, from the peak at 1116:30 UT (50.5° ILAT) to 1123 UT (56.8° ILAT), the intensity of the GSE-Z component decreased with increasing latitude, although the intensity fluctuated. The direction of convection at these latitudes is sunward as seen in the lowest panel of Fig. 2. Between 56.8° and 65.0° (1127:30 UT) the peak values of the GSE-X, -Y, and -Z components increased with increasing latitude, and the polarities of the three components changed several times at these latitudes. The lowest panel in Fig. 2 shows that the direction of convection is equatorward at latitudes from 57° to 62° ILAT and antisunward at latitudes higher than 63° ILAT. The direction of convection reversed at around 60° ILAT. No data were obtained on the magnetospheric electron density profile on the pass of March 13.

4. Electric Fields during the Recovery Phase

Figure 3 shows the electric field and the corresponding convection observed on March 14. The upper three panels in Fig. 3 indicate the electric field data on the pass in the northern hemisphere for the period 0810–0829 UT on March 14, 1989. The geomagnetic activity was in a recovery phase during this period as shown by the bar numbered 14 in Fig. 1. The third panel from the top of Fig. 3 shows the enhanced GSE-Z component of 80 mV/m at 0824:30 UT when the satellite was at 19.4 MLT, 53.6° ILAT, and 3600 km ALT. It is estimated to be 130 mV/m when projected to the reference altitude of 120 km. The GSE-Y component is very small compared with the GSE-Z-Z component. The velocity of the sunward plasma con-

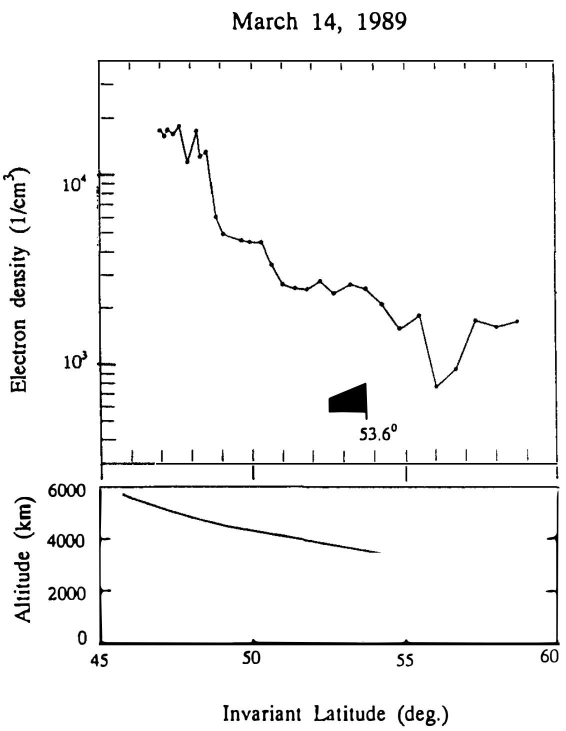

Fig. 4. Electron density profile of the inner magnetosphere deduced from the plasma wave UHR data (OYA et al., 1990) along the orbit during the time 0810–0832 UT on March 14, 1989. The region of equatorward enhanced electric fields is indicated by a solid mark.

vection at 3550 km ALT is estimated to be 5.7 km/s. As is seen from the lowest panel of Fig. 4, the plasma convects sunward at latitudes from 51° to 58° and the maximum velocity is 2.8 km/s at 53.6°. The direction of convection reversed around 60° ILAT. The vectors directed anti-sunward at latitudes lower than 50° indicate the corotation of the plasmaspheric plasma.

Figure 4 shows the magnetospheric electron density derived from the plasma wave measurement onboard the EXOS-D satellite (OYA *et al.*, 1990) and the altitude of the satellite as a function of latitude along the orbit. A solid mark under the electron density profile indicates the latitudinal range of the enhanced electric field. The right side of the solid mark corresponds to the location of the sharply enhanced electric field at 53.6° ILAT and the left side means the latitude at which the electric field intensity is half the peak value. The electron number density changed considerably at around 49° ILAT, decreasing from 1.5×10^4 cm^{-3} at 48.5° ILAT to 2.7×10^3 cm^{-3} at 51.0° ILAT. This sharp decrease in the electron density near 49° ILAT indicates a plasmapause crossing. It is clear that the electric field was enhanced in the low electron density region outside the plasmapause.

5. Discussion

SOUTHWOOD and WOLF (1978) have suggested that intense poleward electric fields occur in the region between the inner edge of the plasma sheet ions and the low-latitude edge of the electron precipitation when these edges are close to each other. This is because the electric equipotential surfaces tend to be confined between the inner edge of the plasma sheet ions (earthward of which the electric field is shielded) and the region of the plasma sheet electrons (where the electric field is weakened due to the enhanced ionospheric conductivity). If the intense electric field is due to the mechanism suggested by SOUTHWOOD and WOLF, this means that the inner edge of the plasma sheet protons was located outside the plasmapause at this time. Although such a configuration is contrary to what is expected on the dusk side under the steady condition of the plasma convection (NISHIDA, 1966; BRICE, 1967), there seems to be a possibility that the outer plasmasphere had been eroded during the early part of the storm main phase and had not yet recovered when the observations were made, so that it was located far inside the inner edge of the plasma sheet protons.

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