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Large-scale electric field in the inner magnetosphere during geomagnetic storms

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It has been well-known from the observation and simulation results that an enhancement of convection electric field in the entire region of the inner magnetosphere and ionosphere takes place during the main phase of geomagnetic storms and that the energetic particles are injected from the nightside plasmasheet into the inner magnetosphere due to the large-scale convection electric field. The recent CRRES [Wygant et al., 1998] and Akebono [Shinbori et al, 2005; Nishimura et al., 2007] satellite observations reveal that a strong large-scale electric field with spatial inhonogeneity is formed in the near-Earth inner magnetosphere in this period. However, due to the lack of the ionospheric electric field observation in the middle-latitude and sub-auroral region, details of time and spatial evolutions of the electric field distribution in these regions during geomagnetic storms have not yet been clarified. In the present study, in order to clarify time and spatial evolutions of the electric field in the middle-latitude, sub-auroral and polar cap ionosphere during the geomagnetic storms, we have performed statistical analysis of the long-term electric field observation of the Akebono satellite for about 7 years from March, 1989 to January 1996.

In the present data analysis, we defined the phenomena of magnetic field disturbances indicating the minimum value of less than -40 nT in the SYM-H index as the geomagnetic storm, and selected 1725 cases of the geomagnetic storms during the above period. Here, we defined the periods of negative and positive values of dSYM-H/dt as the main and recovery phases of geomagnetic storms, respectively. Moreover, we divided the recovery phase into two stages: the periods when the SYM-H values give less than -40 nT and more than -40 nT are defined as the early and lately recovery phases, respectively. We also identified the magnetically quiet condition periods when the SYM-H and Kp indices represent more than -10 nT and less than 2. On the other hand, in the electric field data analysis, we used the mapping method into the ionosphere proposed by Mozer [1970], using the IGRF90 model field.

During a magnetically quiet condition, the electric field distribution and the potential structure in the high-latitude region of more than 60o show a typical structure of the electric field indicating the two-cell convection pattern. In the polar cap region, the dawn-to-dusk electric field appears with the averaged magnitude of 10.0-20.0 mV/m. In this case, the potential drop in the polar cap region can be estimated as about 26 kV.

During the main phase, the electric field intensity in the auroral zone and polar cap region increases by 2-3 times amplitude and the polar cap region expands into the low-latitude region, compared with that during the magnetically quiet condition. In this case, we can estimate the polar cap potential as about 80 kV. Moreover, a new component of the poleward electric field appears in the sub-auroral region in the local time sector between 18 and 24h with the averaged magnitude of 40-60 mV/m without the azimuthal component. On the other hand, the potential distribution of the electric field shows the negative potential stricture in the dawn sector between 03 and 06h with the potential drop of about 4-6 kV.

During the early recovery phase, the polar cap boundary moves into the high-latitude region from 70 to 74o and the poleward electric fields clearly appear with the double structure in the auroral zone and sub-auroral region in the dusk sector between 18 and 23h. The poleward electric field in the sub-auroral region can be identified as the SAID/SAPS phenomena. Moreover, in the equatorward region of the poleward electric field, the shielding electric field appears with the magnitude of 5-10 mV/m. During the lately recovery phase, these electric field distributions and potential structure recover to the magnetically quiet level.