Penetration of the polar electric field to low latitudes during the geomagnetic storm

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http://www2.crl.go.jp/dk/c231/index.html

An outstanding geomagnetic storm occurred on November 6, 2001, because of the extremely large amplitude southward IMF (-50 nT). The polar cap potential (PCP) developed considerably for two hours after the arrival of the solar wind shock as observed by magnetometers in the polar cap. After a short-term recession, the PCP increased again for other two hours because of the southward IMF. The SYM-H derived from low latitude magnetic disturbances decreased rapidly down to –330 nT in one hour from the SC. The geomagnetic storm then turned into the recovery phase with the SYM-H increasing gradually. The first increase in the PCP caused development of the ring current, but the second increase did not intensify the ring current. One of the purposes of the present paper is to confirm that the penetration of the convection electric field to low latitudes is closely related to the development of the ring current. Another purpose is to provide an idea about what causes the recovery phase even when the convection electric field remains high.

It was found that the geomagnetic storm was anomalously amplified at the dayside dip equator (Yap) as compared with that at low latitude in the same meridian (Okinawa). The geomagnetic field at Okinawa started to decrease immediately after the SC and decreased down to the amplitude of 300 nT in about one hour from the onset of the SC in a similar manner to the SYM-H. The geomagnetic storm on the other hand, was considerably amplified with the amplitude of 700 nT at the dayside dip equator. The anomalous amplification of the equatorial geomagnetic storm implies a superposition of magnetic effects of ionospheric currents on the magnetic disturbance due to the magnetospheric currents such as the magnetopause currents and the storm-time ring current. By assuming that the geomagnetic storm at Okinawa was totally caused by the magnetospheric currents, we distinguish the ionospheric current component (DP component) of the geomagnetic storm from the magnetic disturbances due to the magnetospheric currents, which was generated in the polar ionosphere. It is remarkable that the DP current in the dayside equatorial ionosphere is eastward during the first two hours in correspondence to the increase in the PCP, while it turned westward during the following two hours, although the PCP increased again to the same order of amplitude as the first increase in the PCP. The reversed current may represent the over-shielding effect caused by the R2 FACs that have been developed by the increased R1 FACs (Kikuchi et al., JGR 2003, A11). The temporal behavior of the eastward equatorial current suggests that the convection electric field penetrated to the low latitude immediately after the SC, while the shielding effect became effective one hour after the onset of the SC, in agreement with the initiation of the recovery phase seen on the SYM-H. Therefore, the reduction of the convection electric field at low latitudes played a role in initiating the recovery phase of the geomagnetic storm. The PCP increased again during the second two-hour period, and the DP current increased correspondingly but remained negative because of the dominant overshielding electric field. The dominant shielding effect may have prohibited the ring current from developing again even if the PCP developed to the same order of magnitude as the first increase. Consequently, the penetration of the convection electric field to low latitudes causes the development of the ring current, while the shielding/overshielding causes the recovery phase of the geomagnetic storm.