磁気嵐時におけるグローバルな地磁気変動と電離圏擾乱ダイナモについて

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Global geomagnetic field variation and ionospheric disturbance dynamo during geomagnetic storms

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It has been well-known that two-cell ionospheric convection in the polar ionosphere driven by a dawn-to-dusk electric field which carries the region-1 (R-1) field-aligned currents (FACs) are significantly intensified and expand to middle-low latitudes during the main phase of geomagnetic storms. The two-cell ionospheric currents produce negative and positive disturbances of the H-component of geomagnetic field in the morning and afternoon sectors, respectively. The dawn-to-dusk polar electric field penetrates to the magnetic equator, and drives the eastward equatorial electrojet current (eEJ) due to the Cowling effect in the daytime sector. During the recovery phase which is caused by the weakness of southward interplanetary magnetic field (IMF) or northward turning of the IMF, the two-cell ionospheric currents in the polar ionosphere are abruptly reduced and the equatorward boundary of auroral electrojet currents (AEJ) move to high latitude. In this case, the magnetic field at the magnetic equator show a significant enhancement of negative variations of the H-component in the daytime sector produced by the westward equatorial electrojet current (wEJ) driven by the dusk-to-dawn electric field originating from the R-2 FACs. On the other hand, after the end of a storm, other types of ionospheric electric field are generated due to the dynamo action of storm-related thermospheric winds generated by auroral Joule heating. The ionospheric electric field has been called dysturbance daynamo field. The electric field drives the wEJ near the equatorial region, whose direction is the same as that originating from the R-2 FACs. However, due to the lack of geomagnetic field data in the middle-low latitudes, detailed relationship between the magnetic field variations of high-middle latitudes and at the equator during geomagnetic storms has not been clarified yet. In this talk, we investigated time and spatial evolutions of global geomagnetic field variations from high-latitude to the magnetic equator during the geomagnetic storm occurred on May 23-24, 2002, using geomagnetic field data with time resolution of 1 minute obtained from the CARISMA, GIMA, IMAGE, MACCS, and NSWM networks, and provided from WDC geomagnetism in Kyoto. We also analyzed neutral winds in the lower thermosphere and mesosphere (70-100 km) estimated from the MF radar at the Syowa station in order to clarlify a change in the background winds and atmospheric tidal waves during the storm.

In the present analysis, we first subtracted geomagnetic field variations during a magnetically quite day (May, 31, 2002) from the disturbed field during the geomagnetic field for each station. As a next step, we excluded the magnetic effects produced by magnetospheric currents (for example, ring current) by subtracting the low-latitude (10-20 degrees, GMLAT) geomagnetic field variation of the northward component. For derivation of the 24-hour and 12-hour atmospheric tidal waves in the lower thermosphere and mesosphere, we adapted the Lomb-Scargel method proposed by Hocke and Kampfer [2009] for 5-day composite average of the zonal and meridional winds.

The equivalent current system showed that two-cell ionospheric currents are significantly enhanced in the daytime sector together with a strong enhancement of the eEJ at the daytime equator during the main phase of the geomagnetic storm. The centers of these vortices were located at 70 degrees and 65 degrees in the morning and afternoon sector, respectively. The two-cell ionospheric currents expanded to the low-latitude region of less than 30 degrees (GMLAT). In the nighttime sector of middle-low latitudes, the arrows of the equivalent current were directed in the northward direction. This signature indicates that the nighttime magnetic field signatures are produced by the magnetic effect of the R-1 FACs. On the other hand, during the recovery phase associated with strong northward turning of the IMF, the equivalent current system showed that the two new vortices different from two-cell ionospheric currents driven by the R-1 FACs system appear in the polar cap and middle latitude. The former led to the enhanced NBz current driven by the lobe reconnection due to the strong northward IMF, while the latter was generated by the enhanced R-2 FACs produced by the strongly asymmetric ring current flowing westward in the inner magnetosphere. In this case, the equatorial magnetic field variation showed a strongly negative signature produced by the wEJ current due to the dusk-to-dawn electric field. Therefore, it seems that the enhanced NBz current system plays an important role in the intensification of the dusk-to-dawn electric field from the middle-latitudes to the magnetic equator.

The height profiles of the amplitudes of 24-hour and 12 hour tidal waves showed a significant enhancement of zonal component in a region from the mesopause to the lower thermosphere (80-100 km) after the end of the storm. The maximum amplitudes of the 24-hour and 12 hour tidal waves reach 20 m/s at 80 km and 30 m/s at 94 km, respectively. However, the well-defined amplitude variations of both the 24-hour and 12-hour tidal waves can not be seen in the meridional component associated with the geomagnetic storm. On the other hand, the phase-height relationship of only the 24-hour tital waves of the zonal and meridional components showed a significant change after the end of the storm. The phase of zonal component moved to the late hours in a height range of 72-90 km. The maximum movement is 9 hours at 78 km. The phase of meridional component also indicates a similar tendency in a whole height range, but the phase difference increases with incresing height. From the present analysis of the tital waves in the polar region, it can be concluded that the variations of the amplitude and phase of atmospheric tidal waves show a complicated response for geomagnetic storms. In the future, we need to analyze the atomospheric tidal waves using the multi-observation data obtained from the MF and meteor wind radars for many storm events.