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Study of mid-latitude ionospheric convection with SuperDARN Hokkaido radar

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Characteristics of ionospheric convection in the mid-latitude and sub-auroral regions have been studied by various kinds of observation instrument and computer experiments in the last few decades. Westward flows around midnight frequently observed at mid-latitudes have been extensively discussed. This kind of flow can be generated by so-called disturbance dynamo mechanisms working at mid-latitudes (Blanc and Richmond, JGR, 1980). Kumar et al. (2010, JGR) reported, using the data from Digisonde drift measurements at Bundoora (145.1 degrees E, 37.7 degrees S geographic, 49 degrees S magnetic), Australia, that the major storms affects the nighttime mid-latitude ionosphere for several tens of hours. In order to understand the influence of disturbances dynamo effects at the mid-latitude region, it is necessary to study the latitudinal distribution of westward flows.

The mid-latitude ionospheric convection characteristics have been studied extensively with the IS radar such as the Millstone Hill radar. However, most of the studies reported on the ionospheric convection characteristics at a fixed latitude with IS radar owing to the limitations of its operation. It is considered that it is more effective make two-dimensional observation such as the SuperDARN radar and the low-altitude satellite. Among them, the low-altitude satellite monitor the ionosphere with certain MLT / latitude region every 1 hour and 40 minutes approximately, so that monitoring of the ionospheric with high time resolution is impossible. On the other hand, most of the SuperDARN radars were set up in the high latitude region, and the observation of the HF radar in the mid-latitude region did not exist until recently. Because the mid-latitude region from 40 to 50 degree is not covered in the observation until the full deployment of the SuperDARN Hokkaido radar in December 2006, detailed study of the mid-latitude ionospheric convection using the SuperDARN was impossible.

In this study we use ionospheric echo data obtained by the SuperDARN Hokkaido radar for 5 years (since December 2006). The SuperDARN Hokkaido radar has been measuring line-of-sight velocities of ionospheric irregularities, which can be regarded as line-of-sight velocities of ionospheric convection, at mid-latitude (geomagnetic latitude: 40 to 60 degrees), which could not be monitored by using preexisting SuperDARN radars.We found the presence of westward flows around midnight at about 40 to 55 degrees geomagnetic latitude. In addition, the data showed that the westward flow around midnight was intensified under high geomagnetic activity (high Kp). This suggests that the disturbance dynamo is effective on the mid-latitude ionospheric convection.

Moreover, Superposed Epoch Analysis (SEA) has been performed in order to study the influences from the storm and substorm at mid-latitude ionospheric convection. We found during major storms (minimum Dst below -60nT), intense westward flows in the nighttime mid-latitude (geomagnetic latitude: 43 to 59 degrees) ionosphere were observed, lasting up to about 30 hrs after storm onset. However, A westward flow was observed even before the onset of storms, possibly due to the influence of substorm. In order to clarify the substorm effects in the next step, Superposed Epoch Analysis (SEA) is performed to study temporal and latitudinal dependence of the influences from substorms. From the analysis of 30 events of AL-defined substorms, we can see that the influence of substorms lasts up from 5 to 20 hours after the onset between 44 and 53 degrees geomagnetic latitude. The westward flow at mid-latitude grows to a maximum at 12 hours after the geomagnetic storm onset. This is consistent with the results of numerical simulation of the disturbance dynamo effect by Blanc and Richmond (1980).

Keywords: Hokkaido HF radar, SuperDARN, midlatitude ionospheric convection, disturbance dynamo, storm, substorm