Temporal and spatial variations of ionospheric irregularities around storm-enhanced density on the basis of GPS total electron content data analysis

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It has been well-known that an enhancement of the ionospheric irregularity in the auroral zone and polar cap is caused by auroral particle precipitation and high-speed plasma convection. Recently, Cherniak and Zakharenkova [2016] reported the strong ionospheric irregularities during a super storm on March 17-18, 2015 that were associated with storm-enhanced density (SED) formation at mid-latitudes. However, since they did not analyzed the GPS data with high time resolution, detailed temporal and spatial evolutions of the ionospheric irregularities during geomagnetic storms remain unknown.

In this study, we analyzed data of Total Electron Content (TEC) and Rate of TEC Index (ROTI) provided by NICT in order to clarify the temporal and spatial evolution of storm-time ionospheric irregularities around SED. The ROTI data are often used to identify small-scale (3-30 km) irregularities of plasma density. The two dimensional horizontal maps of ROTI and TEC can be obtained from worldwide GPS data every 5 minutes and 30 seconds, respectively. In the present analysis, we used geomagnetic indices (Kp and Dst) provided by WDC for Geomagnetism, Kyoto University in order to identify several storm events, geomagnetically quiet and disturbed days.
We investigated behavior of TEC and ROTI during large geomagnetic storms that occurred on March 17, 2015 and December 20, 2015. SED were observed during the storms. We found three types of ionospheric irregularities around SED, and named them type A, B and C. Type A had structures of about 100 km and propagates westward at the speed of ~ 900 m/s from the east of SED and merged with the SED. Type B and C occurred at both eastern and western boundary of SED, respectively. We compared these irregularities with plasma velocity obtained by HF radar at Christmas Valley east. It is suggested that type B and C are associated with SED, but type A is not. The generation mechanism of Type B can be explained by gradient drift instability.

Keywords: Geomagnetic storm, Ionospheric irregularity, Global GPS receiver networks, Ionospheric flow, Density gradient drift instability