Large enhancements of global GPS total electron content during a magnetic storm on 7-8 November 2004

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Storm enhanced density (SED) with a latitudinally narrow structure is one of the storm-time ionospheric disturbances in the mid- and low-latitude regions. Foster and Rideout [2007] reported that the SED plume occurs in magnetically-conjugate regions in both northern and southern hemispheres. In this study, we analyzed geomagnetic storm events from 2000 to 2012 and found that a TEC enhancement over Japan on 8 November 2004 is the largest. Maruyama [2006] reported that the TEC enhancement appeared during this event, and pointed out that the mid-latitude TEC enhancement observed after the sunset is related to SED. However, since most of the previous studies focus on TEC variation in a specific region, the detail features of global TEC variation associated with the development and decay of the geomagnetic storm have not yet been clarified. The purpose of this study is to understand the generation mechanism of the TEC enhancement in the mid- and low-latitude ionosphere during the geomagnetic storm using global GPS-TEC data with high temporal and spatial resolutions provided by NICT. The GPS-TEC data have spatial and temporal resolutions of 0.5°×0.5° in longitude and latitude and 5 minutes, respectively. Here, we first calculated a difference value (dTEC) between storm-time TEC and average TEC of 10 geomagnetically quiet days. In this calculation, we referred to a list of geomagnetically quiet and disturbed days provided by World Data Center for Kyoto University. Next, we created a two-dimensional map of rTEC (dTEC normalized by the average TEC of 10 geomagnetically quiet days), and analyzed the temporal and spatial variations of rTEC for a geomagnetic storm which occurred on 8 November 2004 with the minimum SYM-H value of -400 nT at 6:00 UT. As a result, the rTEC enhancement in Japan was maintained even after the onset of the recovery phase, and the maximum value reached ~17 (~90 TECU). The enhanced rTEC region in Japan propagates westward with a velocity of 317 m/s. In order to investigate the specific signature of rTEC in Japan in detail, we created the latitude-time plot of TEC at a longitude 142°E. In this plot, two high TEC regions appear near 5:00 UT and 11:00 UT, and propagate from high to low latitudes. Furthermore, the ion drift meter data obtained from the DMSP satellite traveling over Japan show the westward flow with a velocity of 250 m/s, which is almost consistent with that of the enhanced rTEC velocity. In the two-dimensional global map of rTEC, the TEC enhancements over Japan and Australia occurred simultaneously with a magnetic conjugacy. The rTEC enhancements were larger in the northern hemisphere than that in the southern hemisphere. The rTEC enhancements started near 5:00 UT at magnetic latitude of 50° in both the hemispheres, and propagated from high to low latitudes. In order to investigate the global signature of rTEC over Japan and America, we created the magnetic latitude-time plot of rTEC. As a result, we found that the rTEC in Japan and America showed a large enhancement at 5:00 UT with the maximum values of more than 6. In the rTEC map at 5:00 UT, the enhanced rTEC region existed between America and Japan. This rTEC enhancement is thought as a cause of SED. SED is thought to be caused by the westward plasma transportation in the mid- and low-latitude ionosphere due to the storm-time enhanced SAPS [Tsurutani et al., 2004]. Assuming that the propagation velocity is 317 m/s, it takes 9.5 hours to move from America to Japan. However, the time difference of the onsets of the rTEC enhancement between America and Japan is 6 hours. Therefore, the rTEC enhancement cannot be explained by the above mechanism of the westward transportation. These results suggest that the enhanced TEC region associated with the TEC peak over Japan existed between America and Japan. Therefore, mechanism different from the SED generation can cause large TEC enhancement

during nighttime and have a wide extent of longitude (100°~).

Keywords: Ionosphere, Geomagnetic storm, Total electron content, Magnetic conjugacy

