# Temporal and spatial variations of the total electron content from the high-latitde to equatorial ionosphere during a geomagnetic storm on 27 and 28 Septermber 2017

Atsuki Shinbori[1], Yuichi Otsuka[1], Takuya Sori[1], Takuya Tsugawa[2], and Michi Nishioka[2]
[1]*ISEE, Nagoya University*
[2]*NICT*

When solar wind disturbances with a strong southward interplanetary magnetic field (IMF) arrive at the Earth's magnetosphere, the magnetospheric convection is enhanced via the magnetic merging process between the southward IMF and northward geomagnetic field at the dayside magnetopause. Based on the enhanced magnetospheric convection, a ring current develops in the inner magnetosphere and causes a geomagnetic storm, which is characterized by a significant depression of the H-component of the geomagnetic field in low- and mid-latitude regions. The geomagnetic storm severely changes the electromagnetic and plasma environments in the magnetosphere and ionosphere and the neutral composition of the thermosphere. At the height of the ionosphere, several prominent storm-time ionospheric disturbances are observed over a wide region, that is, from high latitudes to the equator. These phenomena include a tongue of ionization (TOI) at the polar cap, storm-enhanced density (SED) at mid- and low-latitudes, and enhanced equatorial ionization anomaly (EIA) in the equatorial region. Because the spatial distribution of the electron density drastically changes because of these storm-time ionospheric phenomena, electron density disturbances increase the satellite positioning error. Therefore, it is important to monitor the temporal and spatial evolutions of global ionospheric disturbances during the development and decay of geomagnetic storms. In this study, we investegated the characteristics of temporal and spatial evolutions of the total electron content (TEC) enhancement due to SED during a geomagnetic storm occurred on 27 and 28 September 2017 using global TEC data obtained from many global navigation satellite system (GNSS) stations. In the present analysis, we first calculated the ratio of the TEC difference (rTEC) between storm-time TEC value and average TEC value of 10 geomagnetically quiet days in September 2017 to the average TEC value in order to identify the global TEC variation associated with the geomagnetic storm. For identification of the 10 geomagnetically quiet days, we referred to the list of 10 geomagnetically quiet days and 5 disturbed days provided by GFZ German Research Centre for Geosciences (ftp://ftp.gfz-potsdam.de/pub/home/obs/kp-ap/quietdst/). Our analysis results showed that the rTEC enhancement first occurred around morning or afternoon at high latitudes (60-70 degrees, magnetic latitude: MLAT), within one hour after the southward excursion of the interplanetary magnetic field (IMF), and extended to longitudinal directions. From the midlatitude SuperDARN radar observations, we found that an intense plasma flow associated with the enhanced plasma convection was observed with a speed of 400–1200 m/s in the enhanced rTEC region. This plasma flow had a vertical component of ~200 m/s. The vertical plasma flow can uplift the F-region of the ionosphere in the sunlit region by 300 km within 1 hour. The rTEC enhancement at the high latitudes expanded to the low latitudes with some delay (2-3 hours) from the significant enhancements of the Joule heating at the high latitudes. At the same time, traveling ionospheric disturbances (TIDs) propagating to the low latitudes were seen in the detrended TEC data. Later, another rTEC enhancement related to the EIA appeared in the equatorial region and extended to higher latitudes. The mid-latitude TEC enhancement merged with the EIA at low latitudes. The observations of storm-time TEC variations suggest that the initial rTEC enhancement and SED plume produce the enhanced convection flow associated with the strong southward IMF while the mid-latitude broad SED may be generated by the equatorward neutral wind in the thermosphere driven by the Joule heating at the high latitudes. Further, a latitudinally broad and intense EIA is caused by a super fountain due to the prompt penetration of the electric field to the equator.