Observations of Total Electron Content Using Multi-frequency and Multi-constellation Global Navigation Satellite System Receivers

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Total Electron Content (TEC), which is total number of electrons along a ray path from the satellite to receiver, has been obtained from dual-frequency radio signals of the Global Positioning System (GPS). It is widely used to monitor the plasma density in the ionosphere. Recently, multi-frequency and multi-constellation GNSS (Global Navigation Satellite System) receivers have been developed and GNSS signals at three frequency bands from not only GPS but also GLONASS, Galileo, BeiDou and so on can be received simultaneously. Using tri-frequency signals, TEC is estimated from three pairs of the signals so that accuracy of the TEC estimation could be improved. Benefit of the multi-constellation is improvement for spatial distribution of visible satellites. In order to obtain absolute TEC by subtracting instrumental biases inherent in satellites and receivers, spatial uniformity of TEC is assumed. In the method of Otsuka et al. [EPS, 2002], it is assumed that the hourly average of vertical TEC is uniform within an area covered by a receiver; this area corresponds to a surrounding of approximately 1,000 km. This assumption is not valid at equatorial region, where spatial gradient of TEC is large so that the estimation of the absolute TEC is degraded. Recently, we have improved this method by considering spatial gradient of hourly-averaged vertical TEC, and have applied improved method to the GPS-TEC data at mid- and low-latitudes. By using the improved methods, residuals of the least-square fitting procedure are reduced to 15% at mid-latitudes and 43% at low-latitudes compared to those in the original method. By using multi-constellation data, we expect that accuracy of the absolute TEC estimation could be further improved because of high spatial resolution of TEC data.

Keywords: GNSS, ionosphere, TEC, GPS, GLONASS, Galileo

