Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PEM07-16 Room:304 Time:May 22 15:00-15:15

Space weather phenomena in the ionosphere and their effect on GNSS

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The Earth's atmosphere at altitudes from 60 km to 1,000 km is partially ionized by solar EUV, forming the ionosphere. The ionosphere causes group delay, phase advance, and scintillation to space-to-ground radio propagations. The severe ionospheric disturbances can degrade precise Global Navigation Satellite System (GNSS) positioning or navigation. Because the use of GNSS prevails these days, A study of the severe ionospheric disturbances and their effect on GNSS is one of important topics in the space weather. The ionospheric conditions largely vary under the influence of solar, geomagnetic, and lower atmospheric activities. Intense solar flares cause sudden ionospheric disturbance (SID) in the sunlit hemisphere through the ionization process. Geomagnetic storms induce various ionospheric disturbances, such as storm enhanced density (SED), positive and negative ionospheric storms, and large-scale traveling ionospheric disturbances (LSTID). At low latitudes, plasma density depletion region, called plasma bubble, are frequently observed after the sunset during high solar activity period. These severe ionospheric disturbances have been observed with wide-coverage high-resolution total electron content (TEC) maps derived from dense ground-based GNSS receiver networks since mid-1990s. The two-dimensional GNSS-TEC observations have revealed some new aspects of such ionospheric disturbances. We will review severe space weather phenomena in the ionosphere and discuss their effect on GNSS.

Keywords: space weather, ionosphere, GPS, GNSS, TEC, ionospheric storm