Comparative study of low, middle and high latitude ionospheric irregularities over northern hemisphere along 120 – 130° longitude sector

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Abstract

This study investigated the latitudinal distribution of ionospheric irregularities over the northern hemisphere along 120 – 130° E longitude sector. The study used 7 ground-based GPS receivers located along magnetic latitude ranging from 10.3 - 65.7° N. In addition, the study used observations of GPS receivers onboard the Swarm satellites during their passes over the region under study. Observations during geomagnetically quiet days (Kp ≤ 3) of the year 2014 were used. The total electron content (TEC) derived from observations of the GPS receivers were used to compute the rate of change of TEC (ROT) to represent ionospheric irregularities. It was observed that the values of space-based GPS ROT were higher compared to ground-based GPS ROT. This observation was attributed to the effect of relativity on the moving receiver clock. This may be the first study to notice that the speed of the Swarm satellite appears to have a multiplying effect on the ROT data observed by the receiver on the satellite. In this study, the ionospheric irregularities were classified into levels of low (ROT < 0.5 TECU/min), moderate (0.5 ≤ ROT < 1), high (1 ≤ ROT < 2), and extreme (ROT ≥ 2).

The latitudinal distribution of high – extreme ionospheric irregularities depicted concentrations around geographic latitude ranges, 1 – 4° N (mag lat. -10.8 ─ -9° N), 9 – 34° N (mag lat 7.8 – 28.3° N), and 62.5 – 84° N (mag lat. 57,1 – 77.4° N). Our results also revealed that low latitude high-extreme ionospheric irregularities during the day can extend in poleward direction up to geographic latitude 34° N (mag lat. 28.3° N). These day-time ionospheric irregularities might be associated with equatorial E-region irregularities generated due to two-stream instability which develops within the Equatorial Electrojet region when east-west drift velocity of the electrons exceeds the ion-acoustic speed. Over high latitudes, high - extreme ionospheric irregularities during the day and at night can extend in equatorward direction to geographic latitudes 74° N (mag lat. 68.3° N) and 62.5° N (mag lat. 57.1° N), respectively. The high-latitude E-region plasma density irregularities arise when the high latitude ambient magnetic field which is directed approximately vertically to Earth's surface and the ambient electric field transverse to the magnetic field as well as the neutral wind produces E-region field-aligned plasma irregularities. The high latitude F-region irregularities might be attributed to the high-energy particle precipitation, solar wind, and magnetosphere–ionosphere coupling as well as convection of currents due to coupling between high conductive E- and F-regions. The approximate boundaries of low-, mid-, and high-latitude ionospheric irregularities reported in this study could be used to update the existing knowledge on boundaries of ionospheric regions in the literature (e.g., Blaunstein and Plohotniuc, 2008). Future studies may compare the approximate irregularity boundaries reported over the current study area with boundaries over other longitude sectors.

Keywords: Ionosphere, ionospheric irregularities, low latitude, middle latitude, high latitude, Total Electron Content (TEC), Rate of change of TEC (ROT)