First detection of the plasma bubbles over Europe

Iurii CHERNIAK[(1)], Irina ZAKHARENKOVA [(2)]

(1) Space Radio-Diagnostic Research Center UWM. Oczapowskiego 2, 10-719 Olsztyn, Poland

(2) IPGP, 35 Rue Hélène Brion, 75013 Paris, France

Equatorial plasma bubbles (EPB) are plasma density depletions of different scale (50-1000 km) observed in the equatorial ionosphere from the bottomside F region to altitudes more than 1000 km EPB typically occur following sunset and rising in altitude they form elongated, wedge-like structure extending increasingly northward and southward along the geomagnetic field lines. During geomagnetic storms perturbed electric fields can initiate untypical development of EPB due to much larger uplift of the ionosphere to high altitudes where the growth rate of the Rayleigh-Taylor instability is maximized

In this study, we present unique result depicted how European midlatitudes were affected by the severe plasma density irregularities of equatorial origin during an intense storm on 22-23 June 2015. During this geomagnetic storm the prompt penetration electric fields caused the occurrence of plasma bite-outs in the post-sunset sector over the Western Africa low latitudes and large-scale plasma bubbles extended toward Europe.

For the first time using dense GPS and GLONASS observations (~1500 stations), the super bubble signatures were registered in Europe. They were observed more than 8 h (20-04 UT) and covered a broad area within 30^{o}-40^{o} N and 20^{o} W-10^{o} E.

During this particular storm the strong ionospheric irregularities was registered not only in Northern Europe sub-auroral and midlatitudes, but over the Mediterranean region. In this region was developed steep plasma gradients and numerous embedded deep plasma depletions on background of high plasma density; plasma gradients were as large as 5-10 TECU/degree. The signatures of the ionospheric irregularities revealed in the ROTI maps persisted for ~7 hour over wide area within ~30°-40°N and ~20°W-10°E, so, they extended by more than 30° in meridional direction.

These unique results were confirmed by the in situ density and upward-looking GPS data onboard the Swarm satellites at ~500 km altitude and ground-based absolute TEC observations. It was found the close similarity between in situ Ne and Swarm-derived topside vertical TEC suggests that plasma density enhancements and depletions are developed in the topside ionosphere (above ~500 km).

Occurrence of the super plasma bubbles in Europe affected GNSS measurements over number of stations in Spain, Portugal, southern France and Italy and led to performance degradation of the European Geostationary Navigation Overlay Service (EGNOS).