GPS measurements onboard Swarm satellites to study occurrence of the equatorial irregularities in the topside ionosphere

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ABSTRACT

GPS measurements from Precise Orbit Determination (POD) GPS antenna onboard Low Earth Orbit (LEO) satellites can be used as an effective tool for monitoring the occurrence of the topside ionospheric irregularities (above LEO orbit) and may essentially contribute to the multi-instrumental analysis of the ground-based and in situ data. In the present study we analyze the occurrence and global distribution of the equatorial ionospheric irregularities based on the upward GPS measurements onboard the Swarm satellites.

The Swarm mission was launched on 22 November 2013 and it consists of three identical satellites – Swarm Alpha (A), Bravo (B) and Charlie (C) - two of them A&C fly in a tandem separated by 1°-1.4° in longitude at an orbit altitude of 460 km while the third satellite (B)– at an orbit altitude of 510 km. Each satellite is equipped with a zenith-looking antenna and 8-channel dual-frequency GPS receiver that delivered 1 Hz data for POD purposes.

We analyze dataset consisted of GPS provided by the Swarm A and Swarm B satellites with 460 km and 510 km orbit altitude during one full year from August 2014 till July 2015. Additionally, we involved into study the in situ electron density Ne, that concurrently measured by Langmuir Probe (LP) instrument onboard Swarm. To identify the presence of the ionospheric irregularities we have derived and analyzed behaviour of two indices ROTI and RODI based on the rate of GPS TEC and rate of density (LP Ne). The obtained results demonstrate a high degree of similarities in the occurrence pattern of the seasonal and longitudinal distribution of the topside ionospheric irregularities derived on both types of the satellite observations. We found the highest values in the occurrence rate for the March 2015 equinox, the lowest ones – for June 2015 solstice.

We found that the obtained ROTI results based on the Swarm GPS measurements are in a very good consistency with the concurrent in situ plasma measurements derived from the LP instrument. On the other hand, one of the undoubted advantage of LEO ROT/ROTI technique is the fact that while in situ measurements are straight-forward and probe the density point-by-point

along a LEO position, this LEO-based GPS technique can track simultaneously up to 8-12 different GPS satellites in great spatial volume above a LEO and is able to observe irregularities ahead/behind/aside LEO position and for much longer time than in situ cross-section. Thus, even without LP instrument a LEO satellite with a GPS receiver can offer additional contribution to study the plasma density irregularities occurrence on a global scale.

Key words: GPS, topside ionosphere, Swarm, plasma irregularities.

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