Early morning equatorial irregularities detected with space-borne GPS measurements in the topside ionosphere: A multi-satellite case-study

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ABSTRACT

Equatorial plasma bubbles (EPB) are mainly considered as after-sunset and pre-midnight phenomena. In this paper we present observations of EPB in the topside ionosphere at early morning hours (05-08 LT) at the recovery phase of the 18-19 February 2014 geomagnetic storm. This rare type of irregularities was detected in the Pacific sector using GPS-measurements onboard several Low-Earth-Orbit (LEO) satellites. This detection becomes possible only due to very favorable configuration of LEO satellites orbits in space and time. We use a multi-satellite constellation consisted of the three Swarm and one TerraSAR-X satellites, that on 19 February flew in the same region and at similar altitudes ~500 km.

Three identical Swarm satellites and TerraSAR-X are equipped with a zenith-looking antenna and a dual-frequency GPS receiver that delivered raw data with sampling rate of 1 s and 10 s respectively for POD purposes. Firstly, we process the POD data of the onboard GPS receiver to determine the upward total electron content (TEC) between LEO and GPS satellites, viz, topside ionosphere/plasmasphere electron content in the altitudinal range of 500-20,200 km. Then, to study the occurrence of the EPB in the topside ionosphere (above 500 km) we derive and analyze two TEC-based indices: ROT (rate of TEC change) and ROTI (rate of TEC Index), proposed by Pi et al. [1].

For our case study the occurrence of the morning-time EPB in the LEO GPS data was observed for several consecutive satellite orbits from ~11 UT to 16-17 UT on 19 February 2014, which suggests: 1) rather long duration (hours) of favorable conditions for EPB generation, 2) formation and evolution of EPB over wide longitude range of the Pacific Ocean, 3) possible movement of the EPB region in the westward direction (with dawn). Registration of the early morning EPB in LEO GPS data was supported by concurrent in situ (Swarm and DMSP) and ground-based (ionosonde and GPS) measurements. LEO-based GPS technique is found to be essential and promising data-source to study the topside EPB over regions with lack of the ground-based facilities. In addition, we use the Prompt Penetration Model and the NCAR Thermosphere-Ionosphere Electrodynamics Global Circulation Model (TIE-GCM) to identify

the possible mechanisms responsible for the observed phenomenon. The model simulation results indicate the occurrence of the zone with the enhanced vertical plasma drift (~40-45 m/s) due to the disturbance dynamo action in the pre-dawn/dawn sector during 09-17 UT.

Key words: space-borne GPS, Swarm, topside ionosphere, ROTI, equatorial irregularities.

References

[1] Pi, X., A. J. Mannucci, U. J. Lindqwister and C. M. Ho (1997), Monitoring of global ionospheric irregularities using the worldwide GPS network, *Geophys. Res. Lett.*, 24, 2283.

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