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LEO GPS measurements to study the topside ionospheric irregularities

Abstract:
GPS measurements from Precise Orbit Determination (POD) GPS antenna onboard Low Earth Orbit (LEO) satellites can be an effective tool for monitoring the occurrence of the topside ionospheric irregularities 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 ionospheric irregularities during the main phase of the geomagnetic storm of 29-31 August 2004 on the base of LEO GPS measurements, as well as in situ data from CHAMP and DMSP satellites. To study GPS fluctuation activity we used TEC-based indices ROT (rate of TEC change) and ROTI (rate of TEC Index), proposed by Pi et al. (1997). Using the CHAMP GPS measurements, we created maps of GPS phase fluctuation activity and found two specific zones of the most intense irregularities: (1) the region of the auroral oval at high latitudes of both hemispheres and (2) the low latitudes/equatorial region between Africa and South America. At high latitudes, the topside ionospheric irregularities appeared to be more intensive in the southern hemisphere, which is, most likely, due to seasonal variations in the interhemispheric field-aligned currents system. An analysis of multi-instrumental observations reveals reinforcement of the equatorial ionization anomaly after sunset in Atlantic sector on 30 August and formation of the significant plasma depletions and irregularities over a large longitudinal range. Equatorial irregularities were also found in the morning sector at the recovery phase of the storm. In our research of the topside ionospheric irregularities in addition to LEO GPS measurements, we analyze the LEO in situ measurements and in a similar way estimate ROD (rate of density) and RODI values. We demonstrate by ROTI vs. RODI comparison that these two techniques cannot be interchangeable in all cases because of the altitudinal extent of plasma irregularities, however there was found relatively high correlation (R~0.7-0.8) between CHAMP ROTI and CHAMP in situ data (RODI). For the first time, we show that a global distribution of ionospheric irregularities caused the phase fluctuations in GPS measurements from LEO CHAMP satellite. Application of ROTI technique to LEO GPS data shows its sensibility even to a rather moderate geomagnetic storm.