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Session 8A Paper 2

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Three-peak ionospheric equatorial ionization anomaly: development, drivers, statistics

In this work, we discuss such unusual observation as occurrence of three-peak ionospheric electron density structure. It is known that the main feature of the dayside low-latitude ionosphere is the equatorial ionization anomaly, that is also referred to as plasma fountain. The EIA is created by the ExB drift that uplifts the equatorial ionospheric plasma to higher altitudes, and forms the ionization trough at the magnetic equator. The uplifted plasma, in turn, diffuses downward along magnetic field lines into both hemispheres assisted by the gravitational and pressure gradients, and forms two peaks of the plasma enhancements at about 10-15 degrees of latitude from the magnetic equator (the crests of the EIA). During geomagnetic storms, the plasma can be uplifted higher and the EIA crests can travel farther away from the equator.

Besides this “classic” dayside 2-peak EIA structure, it has recently been shown that strong geomagnetic storms can produce 3- or even 4-peak latitudinal structures in the daytime ionosphere. In addition to that, Maruyama et al. (2016, GRL, doi:10.1029/2015GL067321) based on modeling of the December 2012 solstice ionospheric distribution, has shown that 3-peak density structure can occur even under geomagnetically quiet conditions due to the prevailing summer-to-winter thermospheric circulation. Further, Astafyeva et al. (2016, JGR, doi:10.1002/2016JA022641) seem to be the first to present a statistical study of the occurrence of the 3-peak density structure in the electron density based on the analysis of 7 years (from 2003 to 2009) of the in situ data from CHAMP satellite. Analysis of the satellite observations confirmed that the three-peak density structure occurs sufficiently often during geomagnetically quiet time; their 7-year data set showed that the third ionization peak develops in the afternoon hours in the summer hemisphere at solstice periods.

While that first statistical study provided us with some interesting information, several questions remained opened: 1) dependence on geomagnetic activity; 2) whether the 3rd ionization peak can be clearly observed at higher latitudes. It is known that the EIA is the F-region feature, so that we do not expect to see this feature above, for instance, 400-450 km. The previous statistical study was based on 7 years of data from CHAMP satellite that changed its orbital height from ~420 km (in early 2003) to ~320 km (in late 2009). Therefore, it is of interest to analyze other data (for instance, earlier CHAMP years (2000-2002), when the satellite was at ~430-450 km), and/or include data from the recent ESA mission Swarm, which consists of 3 identical satellites flying at 460 km (Swarm A and C) and 530 km (Swarm B).

In this work, we tend to respond on these fundamental questions. For this purpose, we extend the period of statistics for the existing CHAMP measurements, as we add three more years of the enhanced solar activity (2000-2002). This would give more information on whether the 3-EIA peak structure, indeed, occur more often during low solar activity. In addition to this, we add several months of observations from Swarm A satellite (2014 and 2015).