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Longitudinal, UT-, and LT-Variations in the F Region Ionosphere and Plasmasphere at Minimum of Solar and Geomagnetic Activity: Similarities and Differences

Abstract:
The prolonged minimum of solar and geomagnetic activity of the 2007-2009 time periods has presented a unique opportunity to examine the steady-state processes in the ionosphere-plasmasphere system while it was relieved from significant contributions of the solar and magnetospheric activity sources to the upper atmosphere variability. In particular, a clearer picture of the longitudinal and temporal variability patterns across the ionosphere-plasmasphere system has emerged from the global observations of the electron density distributions, thus warranting their careful interpretation and prediction based on the global first principles theoretical and assimilation models.

We present initial findings from our study of the GSM TIP (Global Self-consistent Model of the Thermosphere, Ionosphere and Protonosphere) and IRTAM (IRI-based Real-Time Assimilative Mapping) capabilities to reproduce the main morphological features of the longitudinal, universal (UT) and local time (LT) variations of the ionosphere-plasmasphere system properties. To that end, we are running a massive comparison of the GSM TIP and IRTAM against a variety of the satellite and ground-based observations.

We expect GSM TIP model to reflect the longitudinal and UT variations in ionospheric/ plasmaspheric electron density adequately: this is a first-principle model that takes into account (1) the mismatch between geographic and geomagnetic axes, (2) plasma transport along geomagnetic field lines produced by thermospheric winds through neutral-ion collisions and (3) the zonal and meridional electromagnetic plasma drift. Identification of the main morphological features of the longitudinal, UT and LT variations of F2 peak electron density, ionospheric, plasmaspheric and total electron content during 2009 winter solstice as seen by the GSM TIP and IRTAM will be discussed. The manifestation of the Weddell Sea anomaly and longitudinal structure of the main ionospheric trough (the light ion trough) in the total, ionospheric and protonospheric electron content is considered.

Using GSM TIP model we investigate the longitudinal variations in the O+/H+ transition height that made it possible to estimate the height of the boundary between the ionosphere and the plasmasphere (protonosphere) under the considered conditions. We also analyzed seasonal variations dependence on longitude of the F2 peak electron density and total electron content at a number of mid-latitude stations in the Northern and Southern hemispheres for the year 2009, according to the GSM TIP model results and observational data of the ground network of GPS receivers and ionosondes.

Despite the fact that in general the longitudinal, UT and LT variations in the F2 peak electron

density and total electron content are qualitatively similar to each other, significant differences between them are observed.

The main reason for the differences is the decreasing of the influence of the thermosphere neutral composition on the total electron content variations in comparison to F2 peak electron density. Other reasons will be discussed in detail using GSM TIP results..

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