The Interconnectedness of Ionospheric Phenomena in the Low Latitudes: A Forecasting Sequence for Space Weather

Sovit Khadka1,2, Cesar Valladares3 and, Patricia Doherty2
1Physics Department, Institute for Scientific Research, Boston College, MA, USA
2William B. Hanson Center for Space Sciences, University of Texas at Dallas, TX, USA

Abstract: At equatorial and low latitudes, most of the post-sunset ionospheric plasma behaviors depend on the plasma drifts or electric fields and their drivers, e.g. neutral winds. This process is an indication of the possible connection between pre- and post-sunset ionospheric electrodynamics. Mutual relationship studies provide a possible route to predict the occurrence of plasma density fluctuation and scintillation in the ionosphere during the late afternoon and night respectively based on daytime measurement of the equatorial ionosphere. Present study aims to develop a technique to predict the interconnection of disturbances of afternoon GPS-derived TEC and scintillation after sunset on the basis of noontime electrojet strengths. Through statistical and case study analyses, the drivers of ionospheric scintillation and disturbance events are investigated in light of different databases observed in the American low-latitude sector. In addition, the role played by various input parameters of the equatorial and low-latitude ionosphere and their electrodynamical processes in the development of irregularities and influences of solar activity on space weather variability will also be discussed. These investigations can provide significant advances to improve the predictability of low-latitude space weather events and mitigate their effects on space-based technologies.

BACKGROUND

- Space weather: A broad field covering the conditions of the sun, solar wind, magnetosphere, ionosphere, and thermosphere that can impact the performance and reliability of space-borne and ground-based technological and infrastructure systems and can also endanger human life or health.

- A recent study shows that the equatorial region is more susceptible to space weather than previously thought (example of -40°). The equatorial electrojet (EEJ) is the primary cause of this newly recognized threat, due to its ability to amplify magnetic perturbations from interplanetary shock events by severalfold (Center et al., 2015).

DATA ANALYSIS

- Interestingly, the geomagnetic field strength depends not only on the geodynamics of inner core magnas of the bulk Earth, but also on ionospheric currents due to the E region dynamo at the upper atmosphere. The equatorial electrojet (EEJ) is a narrow, laterally limited (~1.5°) band of intense current flowing at the ionosphere-E region over the dip equator, and produces strong geomagnetic field variations during the daytime.

- The elements controlling the ionospheric weather in the low latitude can be represented by: electric field, ionosphere variations, plasma disturbances, and plasma structures. The sunset electrojet strengths in the ionosphere are responsible for the generation of the plasma bubble that can cause scintillation or even disruptions of satellite and navigation systems (Abdu, 2016).

RESULTS

- The day-to-day variability of peak values of afternoon TEC and anomaly separation is seen on noontime EEJ strengths and the characteristic features of the DA crests exhibit a strong correlation with the EEJ variabilities.

- Minor correlation of peak value of EIA with net 54 index greater than 0.2 likely exists, but there is no correlation at all below 0.2 for the solar minimum year 2008. Noon-time EEJ strengths is not a good predictor for the nighttime scintillation during solar minimum period in the low latitude ionosphere.

CONCLUSIONS

- Day-to-day characteristics of EEJ are a useful tool to probe equatorial and low-latitude ionospheric electrodynamics associated with plasma density variabilities a few hours in advance.

- A clear picture of the linear dependence of peak values of afternoon TEC and anomaly separation is seen on noontime EEJ strengths in the low latitude ionosphere. The day-to-day variability and the characteristic features of the DA crests exhibit a strong correlation with the EEJ variabilities.

- Minor correlation of peak value of EIA with net 54 index greater than 0.2 likely exists, but there is no correlation at all below 0.2 for the solar minimum year 2008. Noon-time EEJ strengths is not a good predictor for the nighttime scintillation during solar minimum period in the low latitude ionosphere.

- As in the polar region, the equatorial region is also highly susceptible to ionospheric scintillations during strong solar activity periods. Extending this analysis to solar maximum with larger database of nighttime S4 index will certainly be worthwhile project in assessing correlations with peak values of daytime EIA.

- Collection of long-term statistics relating magnetometer-driven drifts and radar-measured drifts can contribute significantly to a more economic way to characterize the occurrence of ionospheric irregularities. The development of such model and statistical relations can help in real-time ionospheric monitoring and improvement in GPS navigation capabilities by assessing space weather impacts.

REFERENCES

5. Khadka et al., 2016

Correspondence: khadkas@bc.edu