Low latitude ionospheric variability during solar minimum 2008: Impact of Solar Wind High Speed Streams

Candido, C. M. N.[1], I. S. Batista[1], Becker-Guedes[1], F.; Klausner[2], V., Negreti, P. M. S.[1]
[1.] National Institute for Space Research – INPE – São José dos Campos – SP - Brazil
[2.] University of Vale do Paraíba – UNIVAP – São José dos Campos – SP - Brazil

Abstract (Font: Arial Bold, 9)

The solar minimum period of solar cycle 23 was unusually long and quiet in comparison to previous solar minimum in 1996. Several reports have been analyzing its features and impact under distinct point of view (Solomon et al., 2013; Lei et al., 2008; Verkhoglyadova et al., 2013) . In this work, we analyze the low latitude ionosphere in South America and its behavior under the impact of this peculiar period. The ionospheric variation is analyzed through typical ionospheric parameters such as the vertical total electron content, VTEC, the peak height of F2 layer, hmF2, and F region critical frequency, foF2, in 2008, around the south crest of Equatorial Ionization Anomaly (EIA), in Cachoeira Paulista (45.0 º W, mag. lat: 16 º S, dip angle: -32.3º). We investigate of the role of High Speed Streams (HSSs) on the ionospheric variability.

Introduction

Solar cycle 23-24 was characterized by a very unusual quiet and long low solar activity period, which lasted from 2006 to 2010, with solar minimum in 2008 and minimum in geomagnetic activity in 2009. This peculiar period have inspired new interest about the role of very low solar activity to several interest areas of knowledge such as solar physics, climate, space weather, meteorology, ionosphere. In 2008-2009, the sunspot number presented a minimum only comparable to the observed in 1913, much before the beginning of space age. Several solar indexes presented annual average lower than those observed in previous solar minimum in 1996. We analyzed the ionospheric variability over Brazilian low latitude site in Cachoeira Paulista (45.0 º W, mag. lat: 16 º S, dip angle: -32.3º) and equatorial region, São Luis (44.2º W, 2.33º S, dip angle: −2.7º). The studied region is characterized by the highest negative declination angle in world, and is surrounding by South American Atlantic Anomaly, SAMA, where the Earth's magnetic field has the lowest magnitude. This intermediary region between the equatorial region and the low middle latitude zone is scenery of important ionospheric processes. This singular location enables us to observe distinct ionospheric phenomena coming from equatorial region such as equatorial plasma bubbles, EPBs, the south crest of Equatorial ionization anomaly. Wave activity such as gravity waves (GWs) or meso-scale travelling ionospheric disturbances, MSTIDs, coming from higher latitudes are commonly observed during low solar activity (Cândido et al., 2008). We are interested do investigate the ionospheric variability under the influence of high speed streams during solar minimum period.

Method

The TEC data analyzed in this work were extracted from RBMC/IBGE network station in Brazil. The VTEC values were calculated by using the Nagoya Model (Otsuka et al., 2002). In this model, the instrumental biases from satellite and receiver are removed by a technique based on the least squares fitting procedure. The VTEC are registered for each 10 minutes. Ionospheric parameters such as foF2 and hmF2 were extracted from digisondes installed at CP and SL. Data were manually processed. In order to verify the dominant periodicities in VTEC and hmF2, we performed a spectral analysis by wavelet technique.

Results

During solar minimum of solar cycle #23, the low latitude ionosphere presented lower plasma densities than the previous solar minimum 1996, as seen in foF2 parameters. The diurnal VTEC presents minimum values at nighttime and pre-dawn and maximum at afternoon, around 15 LT. The VTEC values present a remarkable semiannual pattern. VTEC peaks around 15:00 LT in CP which is probably due the contribution of the south crest of EIA over CP. Maximum values were observed in daytime: 36 TECU at CP and 33 TECU at SL. The lowest values of VTEC were observed at nighttime during June solstice. A noticeable day-to-day variability was also observed, especially at low latitude region, CP. Periodicities of 9, 13,5 and 27 days have observed in annual VTEC values, which match to the periodicities observed in solar and geomagnetic indexes. The impact of HSSs is clearly observed at the first and at the second half of 2008. A study case of VTEC variation during an event of HSSs is discussed.

Conclusions

Low latitude ionospheric plasmas densities were observed lower in 2008 than in previous solar minimum 1996. The low latitude ionosphere in Brazilian sector, observed through the VTEC variation, presented a

striking variation associated with the occurrence of high-speed streams during the solar minimum 2008. The influence of HSSs on the ionosphere is variable and may be associated to dynamics processes such as prompt penetration of interplanetary electric field, disturbance dynamo, or to neutral atmosphere processes, as changes in temperature and composition. All of these processes affect the distribution and variation of VTEC both at equatorial and low latitude sites and may last several days, in connection to the recurrent coronal holes and the geomagnetic activity. To study and to understand the solar minimum is currently considered an important task not only to improve technological systems for quiet conditions but to better understand low-to-high atmospheric coupling processes which modify the ionosphere.

Acknowledgments

CMNC would like to thanks to CAPES – Coordenação de Aperfeiçoamento do Ensino Superior for the financial support. We also thank to the technical staff of INPE by instrumental and some data managing. In addition, we thank to IBGE by the maintenance and managing of RBMC network systems.

References

Candido, C. M. N., Batista, I. S., Becker-Guedes, F., Abdu, M. A., Sobral, J. H. A., and Takahashi, H.: Spread F occurrence over a southern anomaly crest location in Brazil during June solstice of solar minimum activity, J. Geophys. Res., 116, A06316, doi:10.1029/2010JA016374, 2011.

Lei, J., J. P. Thayer, J. M. Forbes, Q. Wu, C. She, W. Wan, and W. Wang (2008), Ionosphere response to solar wind high-speed streams, Geophys. Res. Lett., 35, L19105, doi:10.1029/2008GL035208.

Otsuka Y., T. Ogawa, A. Saito, T. Tsugawa, S. Fukao, and S. Miyazaki (2002), A new technique for mapping of total electron content using GPS network in Japan, *Earth Planets Space*, 54, 63–70, 2002.

Solomon, S. C., L. Qian, and A. G. Burns (2013), The anomalous ionosphere between solar cycles 23 and 24, J. Geophys. Res. Space Physics, 118, 6524–6535, doi:10.1002/jgra.50561.

Verkhoglyadova, O. P., B. T. Tsurutani, A. J. Mannucci, M. G. Mlynczak, L. A. Hunt, and T. Runge (2011), Variability of ionospheric TEC during solar and geomagnetic minima (2008 and 2009): external high speed stream drivers, Ann. Geophys., 31, 263–276, 2013.