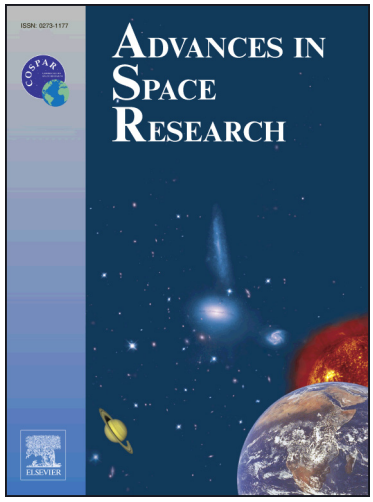

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Ionospheric irregularities over Bahir Dar, Ethiopia during selected geomagnetic storms

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Abstract

We have analyzed the effect of geomagnetic storms on the occurrence of ionospheric irregularities by considering seven case studies in the period of 2013-2014 over Bahir Dar, Ethiopia (11^0N, 38^0E). We inferred the irregularity indices from GPS phase fluctuation by computing the median of 1-min rate of change of total electron content (f_p) along the ray paths from all satellites observed. The F_p-index was calculated as an hourly average f_p-index values along the ray paths from all satellites observed during each hour. Our results revealed that the irregularity level was inhibited during post sunset hours of the main phase of the storms we considered. On average, the irregularity index has dropped from 400 (0.4 TECU/min) during quiet time to 50 (0.05 TECU/min) on disturbed time with an amount of 350 (0.35 TECU/min). However, in some of the cases, immediately after the onset of the storm, we observed the enhancement of irregularities. We found that only the observations on 01 June 2013 and 19 February 2014 exhibited a correspondence of the time of occurrence of the minimum of the Dst-index with inhibition of irregularities noted by other researchers. Our observations of the enhancement of irregularities on 17 March 2013 and 19 February 2014 can partly be explained by the orientation of the IMF B_Z. Other measurements such as neutral wind, electric field are required to explain the observations on 29 June 2013, 06 July 2013, 09 November 2013 and 27 February 2014.

Keywords: Ionospheric irregularity, Geomagnetic storm, Rate of change of TEC

1. Introduction

The quiet and disturbed-time behaviors of F-region ionospheric irregularities in the low latitude have been investigated using observations of satellite measurements, ground-based Global Positioning System (GPS) receivers, scintillation receivers, radars, ionosonde, all-sky imagers. Magnetospheric dynamo electric fields and the disturbed neutral wind dynamo electric fields are reported to be the main contributors for the presence and absence of low latitude F-region irregularities during different storm phases. These fields are capable of disturbing the ionospheric electric field in low latitudes leading to layer height variations of the ionosphere (Fejer, et al., 1990; Spiro et al., 1988; Liang et al., 2008; Purushottam et al., 2011; Malik et al., 2010).

Aarons et al. (1997) and Guozhu et al. (2008) discussed the major characteristics of the storm-related electric fields and their effects on the development/inhibition of the equatorial plasma irregularities. They used ground-based GPS observations to investigate the characteristics of ionospheric irregularities during storm periods.

Similarly, Malik et al. (2010) used GPS observations and reported the strength and occurrence of irregularities increase during the storm periods by examining the GPS phase fluctuation at latitudes near the magnetic equatorial region during the period 3 November 1993 to 2 October 1995. They have concluded that the irregularities on the magnetic equator can be individually and statistically evaluated by GPS phase fluctuation observations.

In another report, Abalde et al. (2009) used the simultaneous observations of the 630.0-nm emission all-sky imager, ionospheric sounding, and GPS phase fluctuation or Rate of TEC (ROT) over Brazil. They have investigated the day-to-day variability in the development of ionospheric plasma bubbles during both geomagnetically disturbed and quiet periods in September-October 2002. They found that the geomagnetic disturbances have a strong effect on the generation and development of ionospheric plasma bubbles during the spring equinox period.

Mendillo et al. (2000) and Li et al. (2010) presented the ionospheric observations of satellite in situ measurements, ground-based GPS total electron content, scintillation receivers, VHF radar, and two chains of ionosonde on the storm days of 22-28 July 2004. They came to conclude that during complex storm periods, long-duration or multiple-penetration electric fields and the combined effects of penetration and disturbed neutral dynamo electric fields could lead to the development of equatorial F-region

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