Study of GPS Ionospheric Scintillation over the Indian Antarctic station, Maitri: Causes and Effect

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Abstract

The auroral region ionosphere is highly variable owing to the existence of open magnetic field line arrangement which allows the direct precipitation of high energetic particles. This causes high latitude region to experience increased scintillations under geomagnetically disturbed conditions. Phase scintillation poses a great concern over high latitude region and can cause cycle slips and degrade the positioning accuracy of the Global Positioning System (GPS) based devices. Auroral scintillation has been studied for decades and is primarily linked with the southward reversal of interplanetary magnetic field (IMF) Bz. The studies concerning the relationship between scintillation activity and relative position of observing station with respect to auroral oval is rather sparse. In this context, an investigation has been carried out on the plausible linkage between the episodes of IMF Bz reversal, phase scintillation activity and the position of the station with respect to auroral oval. The ionospheric scintillation data recorded at the Indian Antarctic research station, Maitri [Geomagnetic latitude 67°S] has been used in the present study. One of the interesting features of the present study is the appearance of daytime scintillations, when the background conductivity is quite high. Results show that the reversal of IMF Bz southward is only the necessary but not the sufficient condition for the occurrence of scintillations at high latitude station, Maitri. Further investigations reveal that the relative position of the observing station with respect to the auroral oval also plays a governing factor for causing the episodes of scintillation over high latitude station. This study would help to improve our understanding of the high latitude scintillations.

1.Introduction

The ionosphere has a significant influence on the navigational systems and satellite communications owing to its influence on the propagation of trans-ionospheric radio waves. Ionospheric disturbances can impair the performance of GPS by causing fluctuations in the amplitude and phase of radio signals that transit the ionosphere, also known as scintillation. Intense scintillations can degrade the signal quality, may increase navigation errors and even cause navigation failure. Strong scintillations are observed over auroral and polar latitudes during disturbed geomagnetic conditions and are associated with large scale plasma structure [1]. Studies have shown the correlation of scintillation occurrence with the southward IMF Bz [2]. The global morphology of ionospheric scintillation activity is well known along with its dependence on solar and geomagnetic activity as well as on season and local time [3]. It is well known that scintillations are not prominently observed during the daytime period because of the presence of enhanced conductivity during this time period which short-out the small-scale irregularities. Thus, the studies showing daytime scintillations are comparatively rare and hence require attention. This paper investigates the occurrence of scintillation activity over the Indian Antarctic research station, Maitri (70.43°S, 11.43°E, GLAT 67.08°S). This station has a unique geophysical location with respect to auroral oval i.e. it remains inside the plasmasphere during daytime under geomagnetically quiet conditions but lies within the auroral oval during disturbed geomagnetic conditions. Thus, the position of the station enables to investigate the effect of location of a station with respect to auroral oval on the scintillation activity.

2.Database

The study is based on the GPS Ionospheric Scintillation/TEC Monitor (GISTM) data which is installed at Indian polar research station, Maitri (70.43°S, 11.43°E, GLAT 67.08°S), Antarctic. The GISTM receiver, model GSV4004, is a Novatel dual-frequency receiver and log raw data on a 50 Hz sampling rate. The occurrence of phase scintillation is characterized by using SigmaPhi index, which is the standard deviation of the detrended carrier phase and computed over 1, 3, 10, 30 and 60 second intervals. In the present work, average values of observed 60-second phase scintillation are used. The IMF Bz data is obtained from Advanced Composition Explorer (ACE) satellite [http://spidr.ngdc.noaa.gov/spidr/].

3.Results and Discussion

Figure 1(a) shows the variation of IMF Bz component, solar zenith angle (SZA) and phase scintillation over Maitri on 15 February 2012. It can be seen from the figure that IMF Bz remains generally southward with few northward orientation episodes on 15 February 2012. In response of this southward reversal of IMF Bz, strong scintillation activity (~0.5) is observed during 2-7 UT. Weak scintillation activity (~0.25) is also observed during 13-19 UT, which represent the daytime period. Similarly, figure 1b shows the scintillation activity on 14 February 2011. It can be seen from the figure that the strong reversal of IMF Bz around 1800 UT is not associated with any phase scintillation activity. Figure 2(a) and 2(b) shows the scintillation activity on 22 and 24 January 2012, respectively. It can be seen from the figures that the episodes of IMF Bz reversal during the dusk time on 22 January 2012 is associated with the scintillation activity; however, same is not true on 24 January 2012. Number of such cases has been identified from the available dataset of 2008, 2010, 2011 and 2012.

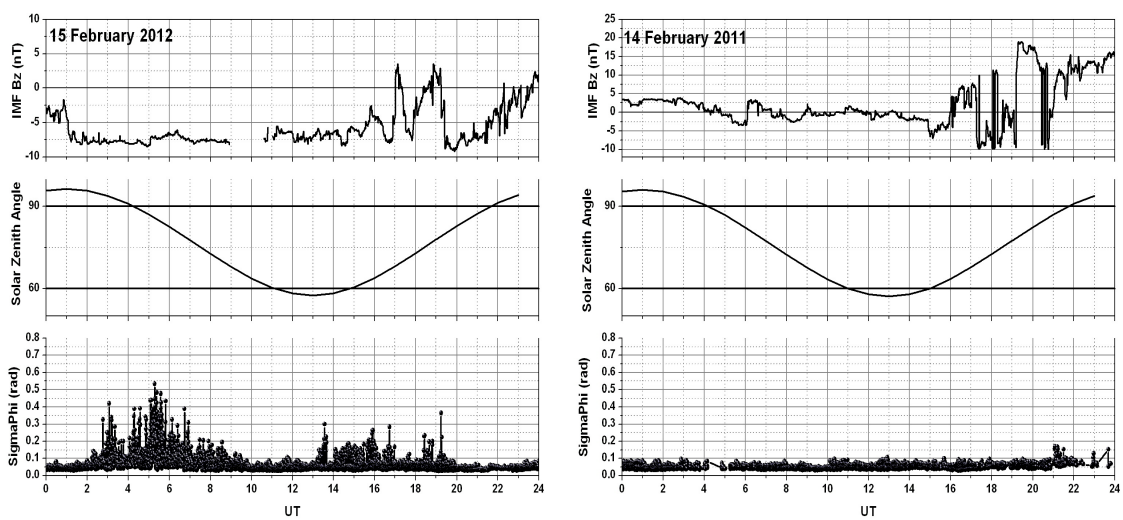

Figure 1(a) **Figure 1(b)**

Figure 1(a) and (b): the variation of IMF Bz, SZA and phase scintillation activity over Maitri on 15 February 2012 and 14 February 2011.

Previous studies have shown that the IMF orientation primarily influence the scintillation distribution in the magnetic local time [4]. It has been reported that the occurrence of scintillation at high latitude station is largely controlled by the IMF conditions [2]. On contrary, our results suggest that the southward turning of IMF Bz can not be invariably linked with the scintillation activity over high latitude station and some other governing factors has to be taken into account. One of the interesting features of the present study is the appearance of scintillation during daytime period when the background conductivity is strong

enough to short-out the ionospheric irregularities causing scintillations. Further investigations reveal that such observation can be ascribed to the location of the station with respect to the auroral oval.

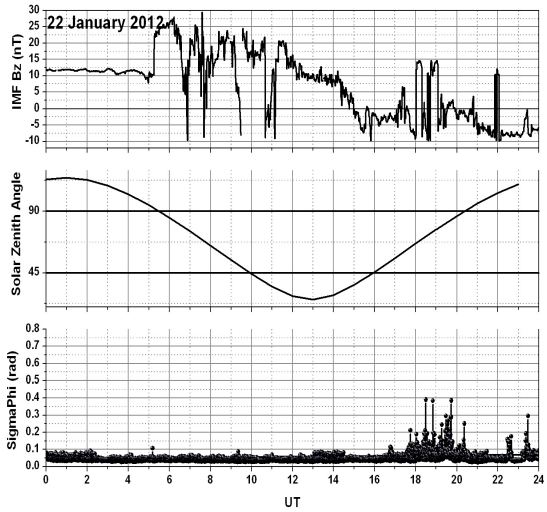

Figure 2(a)

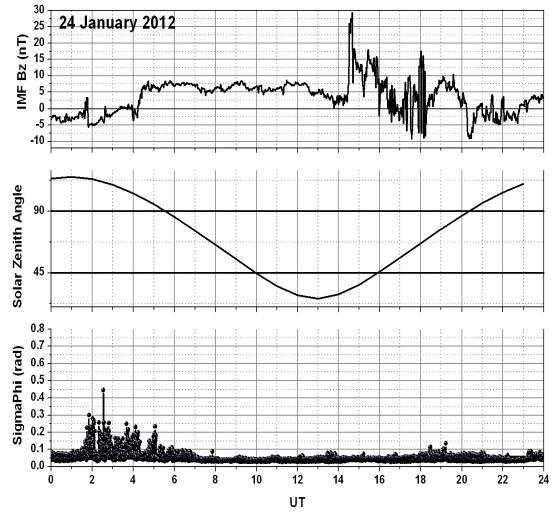

Figure 2(b)

Figure 2(a) and 2(b): the variation of IMF Bz, SZA and phase scintillation activity over Maitri on 22 January 2012 and 24 January 2012.

4.Conclusion

The present study demonstrates the significant influence of location of station with respect to auroral oval on the occurrence characteristics of ionospheric scintillations at high latitude station, Maitri.

5.Acknowledgement

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6.Reference

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