EFFECT OF IONOSPHERIC SCINTILLATION ON GPS RECEIVER AT EQUATORIAL ANOMALY REGION BHOPAL

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ABSTRACT:

Scintillation is a rapid amplitude and phase fluctuation of satellite signal observed near the earth's surface. Radio scintillation is a major problem in Navigation application using GPS and in satellite communication, especially in low latitude, the problem being particularly acute around equatorial anomaly peak region. Severe amplitude fading and strong scintillation affects the reliability of GPS navigational system and satellite communications. Therefore, it is desirable to obtain further understanding of ionospheric scintillation and its effects on GPS by means of a receiver capable of performing in such conditions. In order to study the effects of the ionospheric scintillation on GPS a dual frequency GPS receiver is installed at Bhopal (equatorial anomaly region) in December 2003. Observations of the GPS satellite signals were conducted in January-December 2004 shown in this paper. The results shows that very intense scintillation can degrade GPS location accuracy by limiting the number of satellites available for position Fixes. By loss of phase and code observation, number of satellite observations lost simultaneously and duration and spatial extent of degraded receiver-tracking performance.

INTRODUCTION:

Radio scintillations due to presence of moving irregularities in the ionosphere is a major problem in Navigation applications using GPS and in satellite communication, SATCOM especially in low latitudes, the problem being particularly acute around equatorial anomaly peak region Scintillation refers to rapid phase and amplitude fluctuations of the radio signals observed on or near the earth's surface. Statistically, scintillation tends to be most severe at lower latitudes (within \pm 20 degrees of the geomagnetic equator) due to ionospheric anomalies in that region. It is also strongest from local sunset until just after midnight, and during periods of high solar activity. If sufficiently intense, these fluctuations can dramatically impact the performance of space-based communication and navigation systems. Ionospheric scintillation is the most significant disturbance that can affect GPS users during years of high sun spot activity. In the presence of scintillation, ionospheric modelling can be rendered impractical and receiver performance can be severely degraded. The influence of the ionosphere and a strategy to isolate its effect are issues of major concern for GPS positioning and navigation applications.

The worst source of scintillation is at the equatorial anomaly region, which corresponds to two belts, each several degrees wide, of enhanced ionization in the Flayer at approximately 15° N and 15° S of the magnetic equator. In this region, during the solar cycle maxima periods, amplitude fading at 1.5GHz may exceed 20dB for several hours after sunset [1].

GPS satellites, which are located at semi-synchronous altitude, are also vulnerable to ionospheric scintillation. The ionosphere affects GPS receivers by degrading the signal performance, in some cases causing loss of carrier lock, and by degrading the accuracy of differential corrections. These affects are caused by irregularities of electron density those scatter radio waves at L band frequency and generate amplitude and phase scintillation. Amplitude scintillation causes cycle slips and data losses to occur and phase scintillation generate fast variation of frequency with which the receiver has to cope. Amplitude scintillations induce signal fading and, when this exceeds the fade margin of a receiving system, message

errors in satellite communications are encountered and loss of lock occurs in navigational systems. The nominal signal to noise (C/N_o) ratio for the L1 signal is about 45 dB-Hz, and tracking may be interrupted when signal to noise (C/N_o) is less than 24 dB-Hz. It will be worse for the L2 signal because its power is 6 dB lower than that of L1. During periods of intense scintillation, the availability of carrier phase observations may be limited through loss of signal lock, with a significant impact on precise positioning applications. Such effects have a larger impact on the L2 tracking performance, where codeless and semi codeless technologies are employed to extract the encrypted L2 signal. The tracking performance of a given receiver depends not only on the magnitude of scintillation activity observed, but also on the receiver tracking capabilities.

The reduction in the number of simultaneously useable GPS satellites may result in a potentially less accurate position fix. Since scintillation occurrence is positively correlated with solar activity and the GPS network has received wide-spread use only recently during a quiet portion of the 11-year solar cycle, the true environmental vulnerability of the GPS constellation is yet to be observed. But even during low solar activity levels, it has been shown, under strong scintillation, that the GPS signals cannot be seen through the background noise due to the rapid changes in the ionosphere, even with the use of dual frequency receivers.

Several researchers have studied the impact of scintillation on GPS receiver performance [2-3]. Some studies have showed that ionospheric scintillation causes degradation in the GPS navigational accuracy and limitations in GPS receiver tracking performance [3]

Recent research has shown that tracking performance can vary significantly between receivers, under identical scintillation conditions. In this regard, the aim of present work is to study the impact of ionospheric scintillation on GPS performance during low solar activity.

DATA USED:

The data used for this study has been collected at the Department of Physics, Barkatullah University, Bhopal, India, by using GSV 4004A GPS receiver The GPS receiver, which is NovAtel's Euro4 version of the OEM4 card modified software, can track up to 11 GPS signals at the L1 frequency (1575.42 MHz) and the L2 frequency (1227.6 MHz). It measures phase and amplitude (at 50-Hz rate) and code/carrier divergence (at 1-Hz rate) for each satellite being tracked on L1 and computes TEC from combined L1 and L2 pseudorange and carrier phase measurements. The primary purpose of the GSV4004A GISTM is to collect ionospheric scintillation and TEC data for all visible GPS satellites (up to eleven).

RESULTS:

We divided the whole data into two categories of Q-Days and disturb days. Figure 1 show the total numbers of loss loch occur in Q-Days and D-days for every month. Results shows that number of loss lock is always greater in quiet days as compare to disturb days except in month of September. To study the effect of scintillation on loss of lock we also observed the average of S4 index for quiet and Disturb days. We find that occurrence of S4 index is always greater in Q-days. From this we conclude that the number of loss lock is depending on occurrence of scintillation.

The 'lock time' of the satellite signal is a useful parameter to have access to, for the simple reason that it allows the lock time of the receiver to be observed for each satellite pass. This helps in the initial observation of the noise content of the pass. If the receiver loses lock, or does not maintain lock long enough (i.e. < 240 s), then the data can be disregarded. This is the time it takes for the detrending highpass-fi lter to re-initialise lock of the carrier phase signal.

Figure 2 shows an example of loss of lock and total number of visible satellite in the presence of strong scintillation activity. Panel 1 shows the S4 index, panel 2 shows lock time while pane 3 and 4 shows the CNo and total number of satellite locked during 12 September 2004 for PRN 3. Result shows that with the presence of strong scintillation activity at 0300 UT, the loss lock is occurred and due to this scintillation activity CNo ratio drop and reached its minimum value of 12. As the scintillation activity is increase, the number of satellite tracked by the receiver decreases until by 0300 UT, the GISTM receiver can tracked only 6 satellites. The remaining six satellites could not be loch due to scintillation, due to which GPS receiver performance is suffer and degrade the measurement performance .and the number of satellite locked is decreases.

CONCLUSION:

Equatorial irregularity structures can simultaneously cause scintillation on several satellites during magnetically quiet nights. With the presence of ionospheric scintillation, GPS receivers suffer from losing lock on most of the satellite. Losses of lock occurred specially in Q-days because at low latitude occurrence of scintillation is high during this period. Additionally, amplitude fades can cause the signal to noise ratio (SNR) to drop below receiver threshold. The results shows that very intense scintillation can degrade GPS location accuracy by limiting the number of satellites available for position Fixes.

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ACKNOWLEDGMENT:

The authors wish to acknowledge the financial support from Indo Russian programme (ILTP) from Department of Science and Technology, Government of India, New Delhi. (No. NP-29/JC-11). S.D. acknowledge Council of Scientific and Industrial Research (CSIR) New Delhi, for providing RA fellowship





Figure 2