International Journal of Electronics, Electrical and Computational System
IJEECS
ISSN 2348-117X
Volume 6, Issue 8
August 2017

Academic Science

GNSS Ionospheric Scintillation Monitoring Using GPStation-6 at Low Latitude Ground Station

Dr. P Naveen Kumar, D.Kavitha
Department of Electronics and Communication Engineering
University College of Engineering, Osmania University, Hyderabad

ABSTRACT

Global Navigation Satellite System (GNSS) and its Space Based Augmentation System's (SBAS) performance degrade significantly due to ionospheric scintillation effects in equatorial low latitude region. Ionospheric scintillation is the rapid change in the phase and the amplitude of a radio signal produced by electron density irregularities in the ionospheric layer. The ionospheric scintillation degrades the accuracy and integrity of GNSS.The strong scintillation can severely impact the acquisition and tracking processes in GNSS receivers, causing degradation in user positioning accuracy.In this work, the real time amplitude scintillation data is obtained at Department of Electronics and Communication Engineering, Osmania University, Hyderabad (Lat : 17.42^0 N ;Lon: 78.55^0 E)on a typical day of 20th May 2017 from NovAtel GPStation-6 GNSS ionospheric scintillation and TEC monitor (GISTM) receiver.The considered constellations are; USA' GPS, USSR' GLONASS and Europeans' GALILEO. Currently, only GPS and GLONASS are declared operational and GALILEO is in its development stage. Based on scintillation events extracted from GPStation-6 data, several statistical distributions are established. The obtained results are encouraging and would be helpful in GNSS ionospheric scintillation studies.

KEY WORDS: GNSS, SBAS, Scintillation, GPStation-6, GPS, GLONASS and GALILEO.

1. INTRODUCTION

The ionospheric layer is the upper part of the Earth's atmosphere. It extends from about 50Km to near 1500 Km, which is ionized by solar radiation.The electron densities in the ionosphere vary in complex manner with time, season, and geographical location, solar and magnetic activity. The presence of small scale irregularitiescan disturb the radio frequency (RF) signals causing amplitude and phase fluctuations [1]. One of the possibilities to investigate the influence of the scintillation on GNSS signals is usingthe scintillation indices: amplitude scintillation (S4) and phase scintillation (σϕ) [2]. These indices are used to estimate the fluctuations on the signal intensity and phase. The S4 parameter which is defined as the square-root of the normalized variance of signal intensity over a given interval of time and is given as.

$$S_4 = \sqrt{(<I^2>-<I>^{2)}/<I^2>} \quad (1)$$

Where 'I' is the intensity of signal, symbol '<>' represents averaging and S4 is a dimensionless number commonly estimated over an interval of 60 seconds. Usually, ionospheric scintillation occurs during post sunset hours and it is due to F-layer irregularities [3]. The scintillation at low latitude region is also affected by the growth of irregularities over the magnetic equator. Studies have been carried out on ionospheric scintillations behavior near Equatorial Ionization Anomaly (EIA) crest over the Indian region [4, 5]. This paper investigates the occurrences of amplitude scintillations of GNSS signals. In this work, the GNSS ionospheric scintillation analysis is carried out.

2. SIGNIFICANCE OF AMPLITUDE IONOSPHERE SCINTILLATION

The amplitude scintillation S4 index is a dimensionlessnumber used to represent the scintillation strength. The S4 values less than 0.3 indicate weakscintillation and as S4 approaches '0'it means that scintillation becomes nonexistent and does not affect the signal. The values between 0.3 and0.6 indicate moderate

scintillation and values greater than 0.6 are indicative of strongscintillation and are likely to affect GPS signals.The upper limit for the S4 coefficient is 1.0[6].Moderate and strong scintillations introduce error in carrier phase measurement, which degrades positional accuracy [7].The carrier to noise ratio(C/No) of satellite signals directly get affected by amplitude scintillation. Reducing the amplitude of a radio signal reduces itspower level which directly affects the signal to noise ratio, Signalstrength is generally measured by its carrier to noise density ratio, and it is generally expressed in terms of dBs. The severe scintillation conditions can prevent a GPS receiver from locking on to the signal and can make it difficult to calculate the user position. The severe scintillation conditions can reduce the accuracy and the confidence of positioning results [8].

3. METHODOLOGY

The amplitude scintillation data of considered satellite navigationsystems signal is acquired over low latitude station of Hyderabad(Lat: 17.42^0 N; Lon: 78.55^0 E). In this analysis the GNSS real time scintillation raw data is obtained for a typical day of 20^{th} May 2017 from GPStation-6(GISTM) receiver which is installed in the Department of Electronics and Communication Engineering, Osmania University, Hyderabad (latitude 17.42^0 N and longitude 78.55^0 E). In this workthe considered constellations are GPS, GLONASS and GALILEO. Fromthe real time GPStation 6 data, the parameters such as GPS week, seconds of week, PRN number, Elevation angle, C/No and S4indices are extracted from the raw data using specialized software application.

4. RESULTS AND DISCUSSIONS

The experimental results in this section are discussed in two cases. The Case (i) deals with the variation of amplitude scintillation indices (ASI) with respect to C/No and Case (ii) deals with the comparative analysis of amplitude scintillation of GPS, GLONASS and GALILEO constellations at low latitude station for a typical day.

Case (i): Variation of Amplitude Scintillation Indices (ASI) with respect to C/No

The Fig's (1, 2 and3) shows the variation of ASI (S4) and C/No with respect to UTC time for the considered constellations.

a) GPS Constellation

Here, the real time data is obtained for 31PRN (Pseudo Random Noise) GPSsatellites. The real time data samples are collected for every 60 seconds. The total numbers of ASI obtained on a typical day from 31 PRN signals are 15501 samples.From Fig (1) it is found that the variation of ASI is inversely proportional to C/No for the considered GNSS system. It is observed that the maximum number of scintillation having amplitude scintillation index less than 0.20 andonly two samples of scintillation values are greater than 0.3 at 15.30Hrs local time(10UTC).

b) GALILEO Constellation

The ASI variations for GALILEO constellation are as shown in Fig. (2). The S4 parameter is observed for every one minute. For the considered low latitude receiver station 14,587 scintillation indices are taken from 11 PRN GALILEO satellites over a period of 24 hours. From Fig (2) it shows that the variation of ASI is inversely proportional to C/No for GALILEO systems. From Fig (2) it is observed that maximum number of scintillation events value is less than 0.2 and four samples of scintillation index values are greater than 0.3 at 16.09 Hrs. local time (10.39 UTC).

C) GLONASS Constellation

The S4 parameter variations on a typical day are as shown in Fig. (3). It showsthat amplitude indices measured in real time for a 24 hours period. All 24 GLONASS PRN satellites provided the results. For these PRN satellites, the total 15,794 ASI are collected. The samples are collected for every sixty seconds. It is observed that from Fig (3), the amplitude scintillation directly affects the signal intensity, which is inversely proportional to C/No. From experimental results, it is observed the maximum number of scintillation having

amplitude scintillation index ranging less than0.30 and only one sample value, which is greater than 0.5 at 19:42 Hrs local time (14.12 UTC).

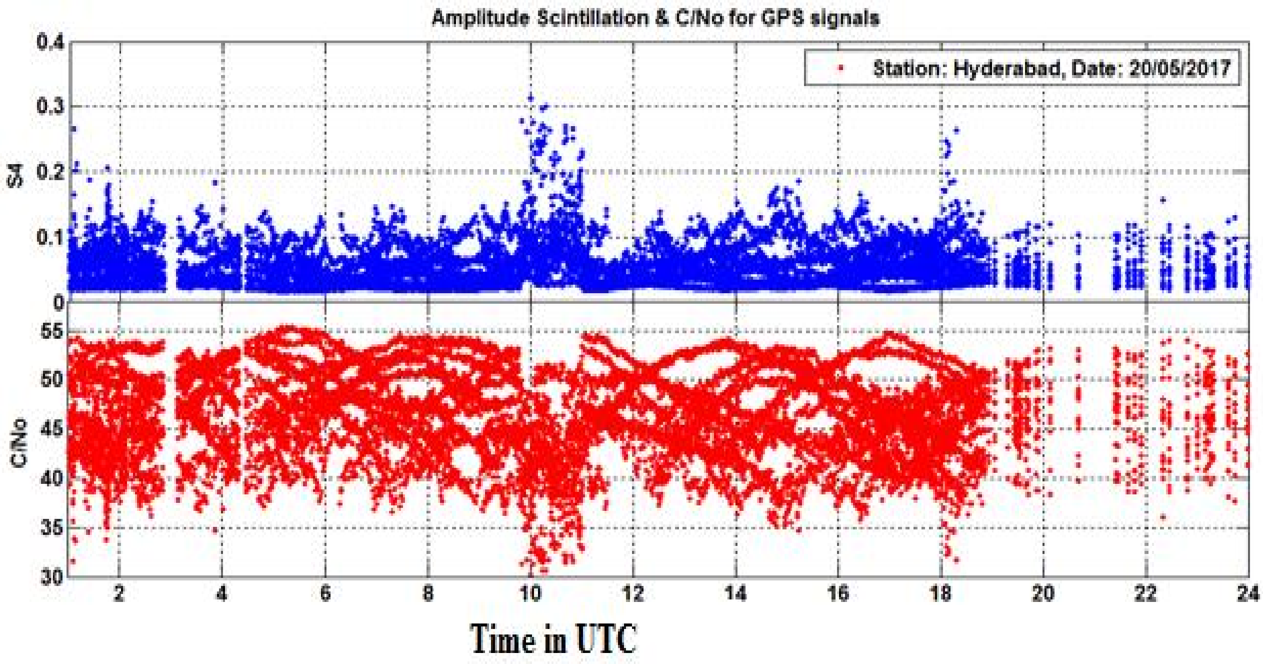

Fig 1: Measured amplitude scintillation and C/No over a 24 hour period for GPS signals at Hyderabad station on 20/05/2017

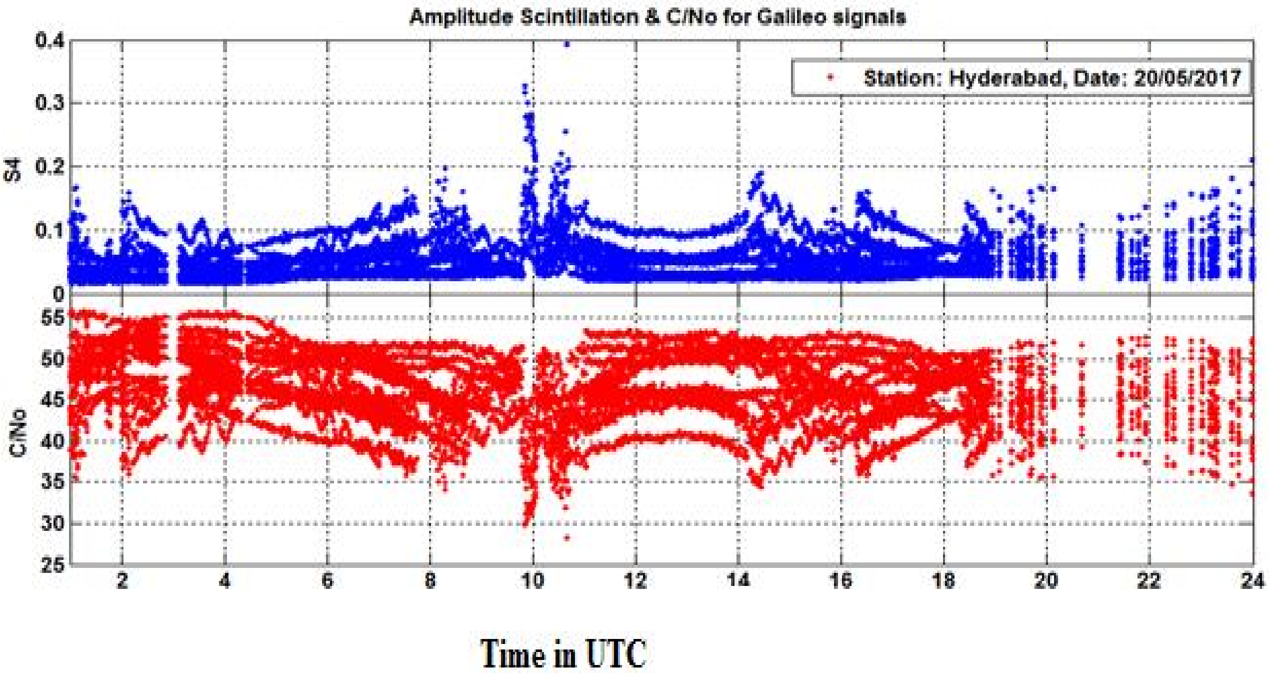

Fig 2: Measured amplitude scintillation and C/No over a period of 24 hours for GALILEO signals at Hyderabad station on 20/05/2017

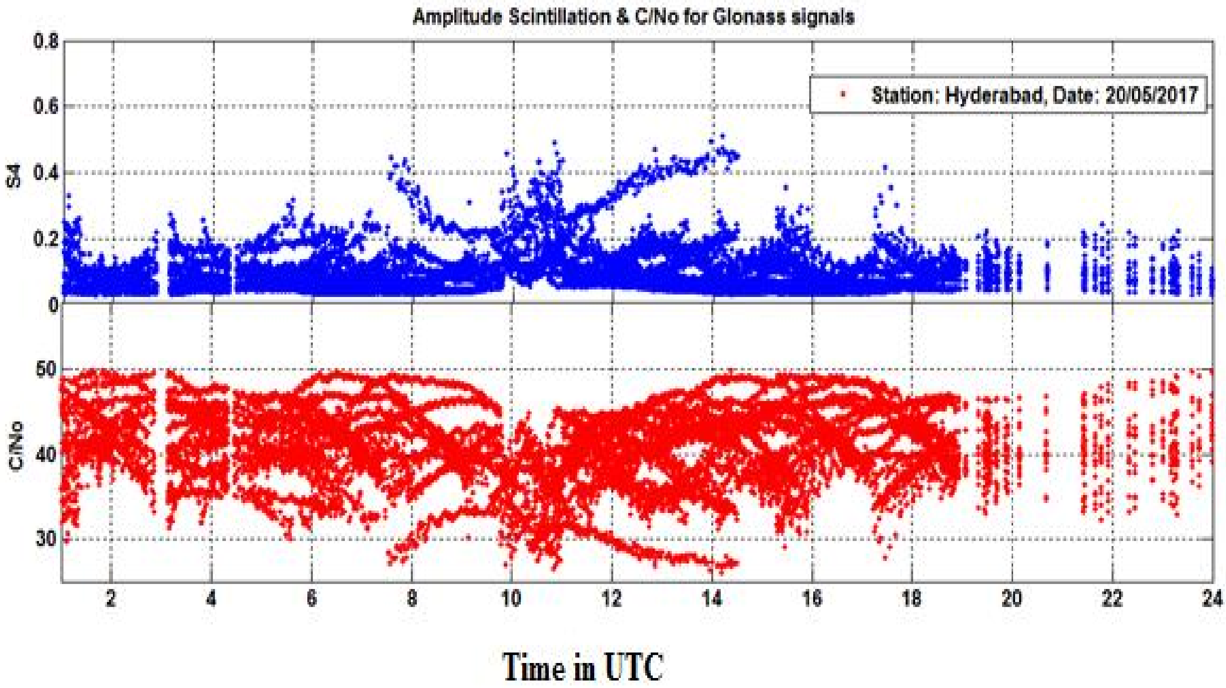

Fig 3: Measured amplitude scintillation and C/No over a period of 24 hours for GLONASS signals at Hyderbad station on 20/05/2017

Table1: Mean values of S4 and C/No of three GNSS constellations

S.No	Constellation	S4 (Mean value)	C/No (Mean value)
1	GPS	0.052823	46.67
2	GALILEO	0.052157	93.39
3	GLONASS	0.199700	82.41

Case (ii):Comparative Analysis of GPS, GLONASS and GALILEO Constellations in terms of S4 and C/No

To investigate the effect of S4 on GNSS signal intensity at low latitude region, three GNSS constellations (GPS, GALILEO and GLONASS) are considered. The table 1 gives the information about the mean values of three constellations. The maximum and minimum S4 and C/No values are recorded for PRN numbers are shown in Fig's (4 and 5).The table 2gives the highest S4 values (0.313705), (0.391967), and (0.510729)for GPS, GALILEO and GLONASS systems at 15.30Hrs, 16:09Hrs and 19:42Hrs local time, it indicates that it is moderate scintillation (0.3>S4<0.6) occurrence. At that time C/No values (30.17), (28.29), and (26.1) are decreased. The table 3 represents the lowest S4 values (0.016959), (0.015903), and (0.032129) are recorded at 10:52Hrs, 6:23Hrs and 7:07Hrs local time. At that time C/No values (55.41), (55.97) and (49.86) are increased. It is found that it indicates weak amplitude scintillation (S4<0.3) occurrence. It is also observed that as elevation angle of all PRN satellites increases the S4 parameter values are decreased. The S4mean value and minimum value of S4is lower for GALILEO system compared to other considered GNSS systems. Compared to GPS and GALILEO systems,S4mean and S4maximum values are greater for GLONASS system.

Academic Science

International Journal of Electronics, Electrical and Computational System
IJEECS
ISSN 2348-117X
Volume 6, Issue 8
August 2017

Table2: Comparison of GPS, GALILEO & GLONASS signals for maximum S4 values

S.No	PRN No.	Constellation	Local Time in Hrs	S4(Max)	C/No (Min in dB)	Elevation Angle(in deg)
1	3	GPS	15.30	0.313705	30.17	7.16
2	8	GALILEO	16.09	0.391967	28.29	5.61
3	24	GLONASS	19.42	0.510729	26.1	7.04

Table3: Comparison of GPS, GALILEO & GLONASS signals for minimum S4 values

S.No	PRN No.	Constellation	Local Time in Hrs	S4(Min)	C/No (Max in dB)	Elevation Angle(in deg)
1	9	GPS	10.52	0.016959	55.41	80.17
2	2	GALILEO	6.23	0.015903	55.97	81.48
3	10	GLONASS	7.07	0.032129	49.86	56.84

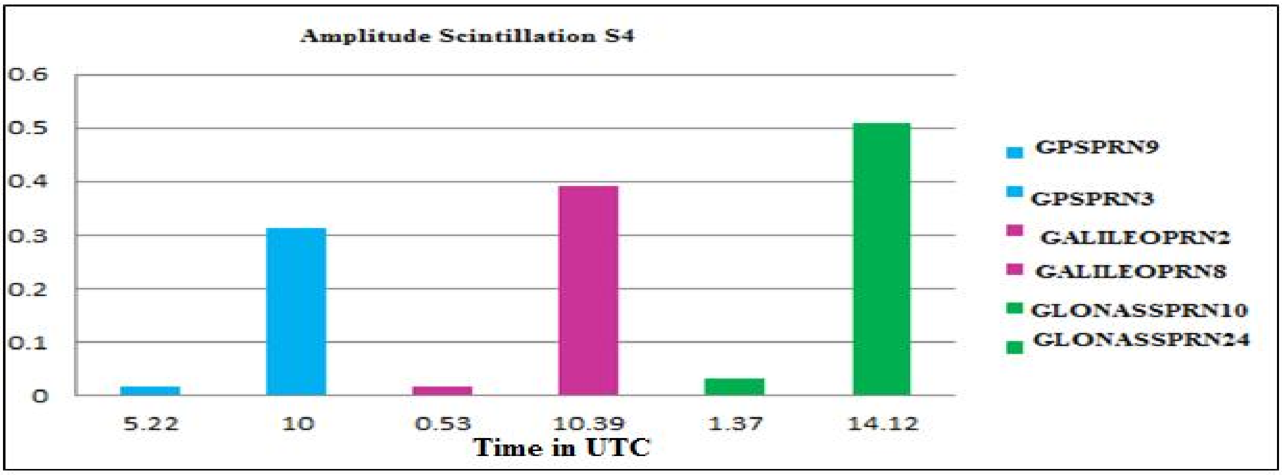

Fig4: Maximum & Minimum S4 values of GPS, GALILEO & GLONASS

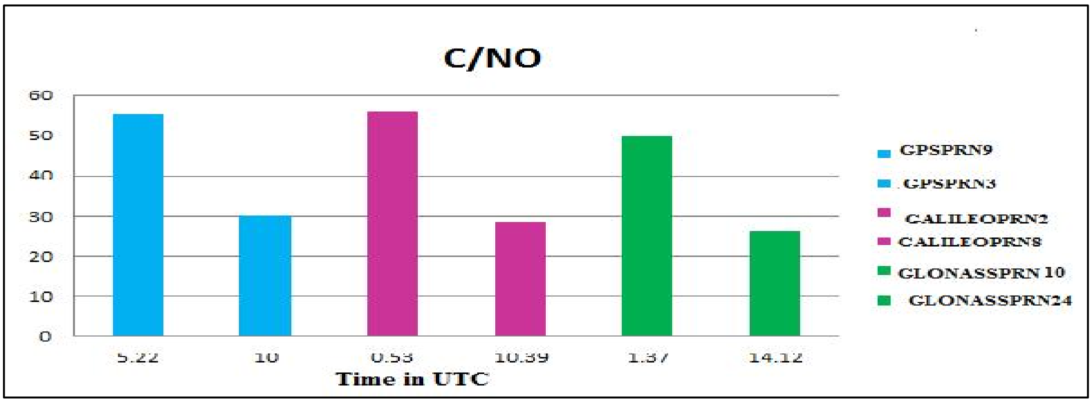

Fig5: Maximum & Minimum C/No values of GPS, GALILEO & GLONASS

5. CONCLUSION

Ionospheric scintillation over low latitude region plays crucial role in the performance of GNSS. In this paper, an ionospheric scintillation results observed for three constellations at Hyderabad low latitude station are presented.It is observed that the amplitude scintillation effect is severe for GLONASS constellation when compared to other constellations on a typical day of 20th May 2017 from Hyderabad station. It is found that, highest scintillation observed for GLONASS system (0.510729) and its resultant C/No is reduced to 26.1dB for PRN 10.The value of C/No dropped to closer to the receiver tracking threshold value (25 dB). Hence, conclude that amplitude scintillation directly proportional to thecarrier to noise ratio (C/No) of signals in a GNSS receiver and results in reduced user position accuracy.

REFERENCES

[1].Groves K. M., Basu Su. And Sultan P. J.. Specification and forecasting of scintillationsinCommunication/ navigation links: current status and future plans. Journal of Atmospheric and Solar-Terrestrial Nov. 2002. 64: pp. 1745-1754.

[2].Butcher N.,"Daily ionospheric forcasting service (DIFS) III" ,Annales Geophysics,23 3591-3598,2005.

[3].Muella M.T.A.H., de paula E.R., Kantor I.J,et al.," GPS L band scintillations and Ionospheric Irregularity Zonal Drifts Inferred At Equatorial And Low Latitude Regions." Journal of Atmospheric and solar-Terrestrial Physics, vol.70, no. 10, pp.1261-1272, 2008.

[4]. Soumi Bhattacharya, Purohit P.K, Rajesh Tiwari and Gwal A.K, "Study of GPS Based Ionospheric Scintillation and Its Effects On Dual Frequency Receiver", Journal of Engineering, Science and Management Education/ Vol.1.2010/55-61,2010.

[5].Vyas B.M and Dayanandam. B, "Night Time VHF Ionospheric Scintillation Characteristics Near the Crest Of Appleton Anomaly Station" Udaipur, IJRSP, Vol.40, p.p191-202, Auguest 2011.

[6].Basu S, Groves KM et al (1999) A comparison of TEC fluctuations and scintillations at Ascension Island. J Atmos Solar-TerrPhys 61(11):1219–1226.

[7]. VincenzoRomano,BrunoBougard,Marcio Aquino, joao F GaleraMonico,TomWillems and Marc Sol. Investigation of Low Latitude Scintillations in Brazil between theCigala Project" proceedings of 3rd International Colloquium on Scientific and Fundemental Aspects of the Galileo Programme,Copenaghen 2011, Published by EuropianSpaceAgency (ESA) Sep-2011.

[8]. Skone,S.,K. Knudsen,M.dejong, " Limitations in GPS receiver tracking performance under ionospheric Scintillationconditions,phys.Chem.Earth (A),26,613-621,2001.