# A comparative study of VHF to S band scintillations around the northern EIA crest of the Indian zone

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## ABSTRACT

### Introduction

Ionospheric scintillation around the equatorial ionization anomaly (EIA) crest is the main constraint for faithful maintenance of transionospheric communication link. The region is plauged by scintillations in the post sunset periods of equinoctial month of high solar activity years. Scintillation causes message error, data loss, cycle slip, loss of lock in the receiving system. To avoid the problem of scintillation multi satellite as well as multi frequency techniques are being utilized. In recently launching Indian Regional Navigation Satellite System (IRNSS) program satellites in Geo-synchronous and Geo-stationary orbits transmitting at L5 and S band and in GAGAN program signals at L1 frequency may judiciously be employed for failsafe navigation. For testing usefulness of Indian augmentation program using IRNSS/GAGAN a study of scintillation features in the said links is the urgent need. In the present investigation a comparative study of the scintillations near the EIA crest at VHF (250.650 MHz), L5 (1176.45 MHz), L1 (1575.42 MHz) and S band (2492.08 MHz) frequencies is presented. It may be mentioned that the observations at S band is presented for the first time from anywhere in the globe.

### Data

Scintillation data at VHF from satellite FSC, at L1 from GAGAN (PRN #128) and at L5, S band from satellite (PRN #3) of IRNSS (IC) recorded at Raja Peary Mohan College (22.65˚ N, 88.36˚ E) are analyzed. The IPP points of the respective satellites are located at 21.1˚N, 86.9˚E (VHF), 21.30˚N 88˚E (GAGAN #128) and 20.96˚N,87.98˚E (IRNSS #3) respectively. It may be mentioned that IRNSS #3 is placed in the GEO ($83^0$E). Scintillation data are categorized on the basis $SI_{dB}$ or S4 values. The data pertaining to quiet geomagnetic conditions are presented.VHF data recorded at 50 Hz while the L5 and S band signals are tracked at 1 Hz. For power spectrum analysis data at weak scintillation conditions ($S_4 < 0.4$) with more or less steady level of fluctuations is selected. The fade rate in the weak scintillation regime is calculated using level

crossing technique while for strong scintillation conditions ($S_4$>0.8) the same is estimated from width of autocorrelation function which is inversely proportional to fade rate.

**Results**

Fig (1) is a sample plot of scintillations at VHF (a) L5 (b) and S (c) band. It is observed that mostly saturated scintillation with P-P fluctuation >25 dB characterize scintillation at VHF. During the period severe scintillation leading to loss of lock of satellite channel are evident in the L5 band. A comparatively weak scintillation mostly limited to <10 dB categorized S band scintillation.

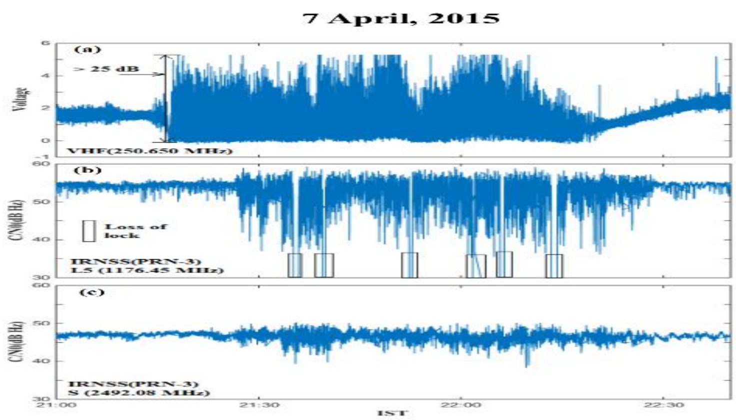


**Fig 1:** Temporal variation of (a) voltage at VHF (250.650 MHz) from FSC, (b) C/N0 (dB-Hz) at L5 (1176.45 MHz) and (c) C/N0 (dB-Hz) at S band (2492.08 MHz) from IRNSS #3 showing scintillation. Blocks in the middle panel indicate receiver loss of lock.

A study of patch duration in the multi frequency band reveals that at SI > 3dB level mostly short duration patches dominates the S band scintillation.For scintillation with SI >10 dB level short duration patches are dominant at L1 while longer duration patches are more visible at VHF and L5 bands. Negligible scintillations are recorded in S band at the said level.

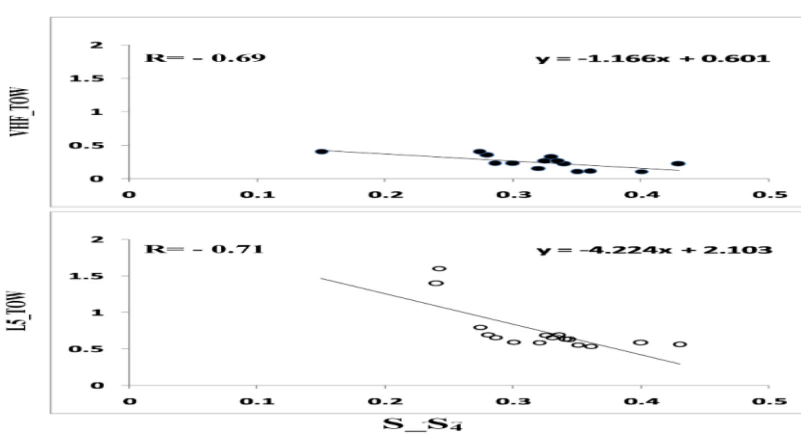


**Fig 2:** Variation of VHF Tow vs$S_4$ at S band (upper panel) and L5 Tow vs$S_4$ at S band (lower panel). Statistically significant correlation coefficient (R) are shown in each panel.

Estimation of fade depth in the weak scintillationregime reveals highest value at VHF (~18 dB) and lowest (~4-6 dB) at S band. Further scintillation at VHF before saturation arefound to be characterize by fast fading rate (~ 50 fade/min) while the fade rates at L5 (~12-15 fade/minute) and S (~5-8 fade/minutes) band are comparatively low.In the saturation regime, fast fading rate as revealed through lower values of $\tau$ (de-correlation time) characterizes scintillation at VHF while comparatively higher $\tau$ value implying slower fading distinguishes the scintillation at S and L5 band.

Assuming S4 at S band as the strength parameter it is observed that (fig.20 as the scintillation intensified fade rate becomes faster and faster at L5 and VHF bands (fig.2).Power spectrum analysis reveals that the spectral index at VHF is observed to increase during 20-22 h IST and it ranges between ~-5.8 to -7 while the same for L5 and S band turns out to be ~-4 to -5.8 and -4 to -5.5 in the said period. The respective Fresnel frequency indicates irregularities in the scale range~800 m control weak scintillation at VHF while at L5 and S band irregularity dimension varies in the range 200-300 m. The coherence length estimated at VHF is found to be much smaller (~4.5m to 15 m) compared to L5 (~68-82m) and S (~70-94m) band signals irrespective of phases and strength of scintillation.

**Summary**

A comparative study of multi frequency extending from VHF to S band, scintillations around the region of EIA crest reveals that scintillations at VHF and L5 band are more severe than weak scintillation at S band.Mostly deep fades with fast fading rate characterize VHF scintillation as well as scintillation at L5 but scintillation at S band is predominantly weak with lower depth and slower fading.Mostly longer duration patches dominates scintillation at VHF and sometimes at L5 while short duration patches are prevalent in S band. The spectral analysis indicates weak scattering is the dominating mechanism for scintillations at S band while the VHF and L5 scintillations are mostly attributed to multiple scattering.

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