

# Study of Ionospheric Scintillation During Low Solar Activity Over Antarctic

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**Abstract**—We have studied the seasonal and monthly occurrence of high latitude L-band scintillations during 2008 at Indian Antarctic station Maitri, by using Novatel's dual frequency GPS receiver GISTM 4004A. The scintillation morphology is described in terms of percentage occurrence in specified threshold level depending on intensity and differential phase of S4 Index. On the basis of S4 Index, the scintillations are categorized as Weak ( $S4 < 0.1$ ), Moderate ( $S4 < 0.3$ ) and Strong ( $S4 < 0.5$ ). From our analysis we found that the occurrences of high latitude L-band scintillations during low solar activity period 2008 were generally of Weak type ( $S4 < 0.1$ ). However, during morning and afternoon hours, slightly higher magnitude scintillations ( $S4 < 0.5$ ) were also observed. The maximum occurrence of scintillations was observed during summer season i.e. between June and December 2008.

**Index Terms**—Polar ionosphere, L-band scintillations, GPS.

## I. INTRODUCTION

The high latitude ionosphere remains turbulent and develops various kinds of electron density irregularities, as a result of several phenomena: characteristic of auroral and high latitude ionosphere. Consequently, the transionospheric radio signals suffer amplitude and phase fluctuation as they encounter these electron density irregularities. These amplitude and phase fluctuation are commonly referred to as amplitude and phase scintillation. Although the occurrence of large scale irregularities is quite common during the high solar activity, small scale structures can develop during the low solar activity periods also. In recent years, observations of GPS scintillations at high latitudes were reported by many authors<sup>1,2</sup>. Using GPS observations from 11 high-latitude stations, Aarons<sup>3</sup> noted that phase fluctuation activity has a daily pattern mainly controlled by the motion of the receiver location into the auroral oval. Mitchell et al.<sup>4</sup> found GPS amplitude and phase scintillation co-located with steep Total Electron Content (TEC) gradient at the southwest of Svalbard during the Halloween storm of October 2003. Later, De Franceschi et al.<sup>5</sup> examined the observations from a chain of GPS ionospheric scintillation and TEC receivers in Northern Europe, and investigated the dynamics of ionospheric plasma during the storm events of 30 October

and 20 November 2003. A strong influence of IMF on the formation and movement of patches was reported.

## II. DATA AND ESTIMATION TECHNIQUE

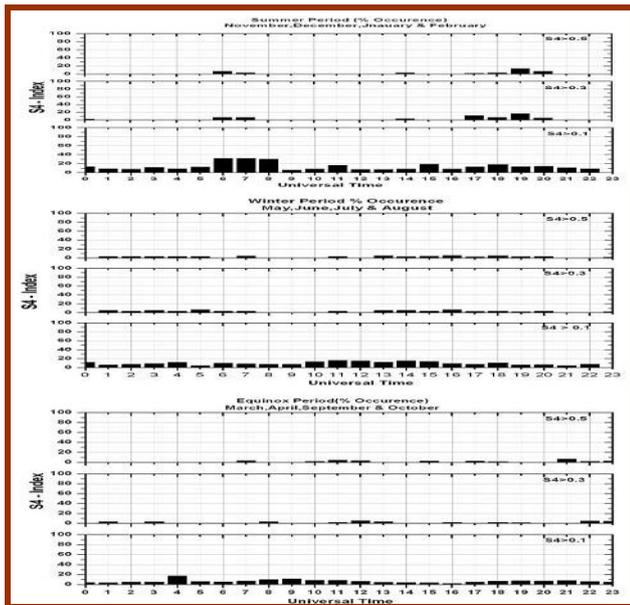
To study the occurrence characteristics of high latitude L-band scintillations, we have used the data recorded by NovAtel's dual frequency GPS receiver GSV4004A operated at Indian Antarctic station Maitri, during the year 2008. The Ionospheric Total Electron Content data were recorded with 30 second sampling rate in order to reduce processing time. The GPS receiver was set to track GPS signals at 1 second sampling rate and cut off of elevation angle was set to 40°. The amplitude scintillation was monitored by computing the S4 index, which is defined as the standard deviation of the received signal power normalized to the average signal power. It is calculated for each 60 second period based on a 50 Hz sampling rate. The S4 index is computed over 60-second intervals and stored in the Ionospheric Scintillation Monitor Receiver (ISMR) data log along with the phase measurements. The normalised S4 index is calculated as:

$$S_4 = \sqrt{\frac{\langle P^2 \rangle - \langle P \rangle^2}{\langle P \rangle^2} - \frac{100}{S/N_o} \left[ 1 + \frac{500}{19S/N_o} \right]} \dots\dots\dots 1$$

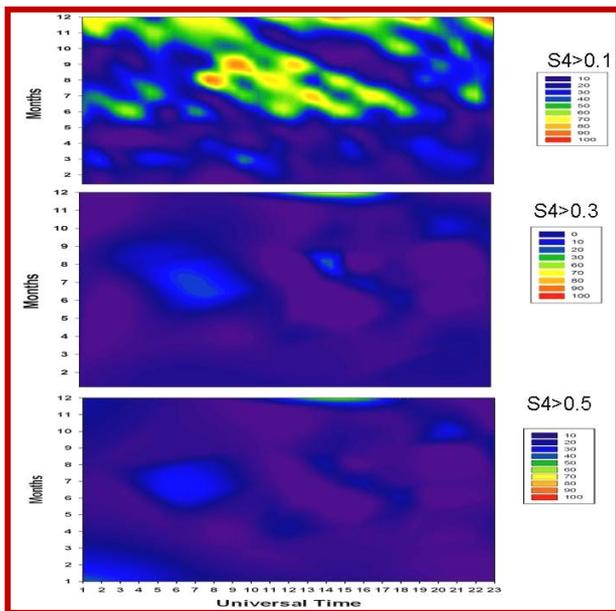
Phase scintillation computation is accomplished by monitoring the  $\sigma_\phi$  index, the standard deviation of the detrended carrier phase computed over 1, 3, 10, 30 and 60 seconds intervals.

## III. RESULTS AND DISCUSSION

The scintillation morphology is described in terms of percentage occurrence in specified threshold level according to intensity and differential phase of S4 – Index. The variation of S4 Index was studied hourly, monthly as well as seasonally. Scintillation are caused by diffraction and scattering of radio waves by free electrons in the ionospheric plasma.



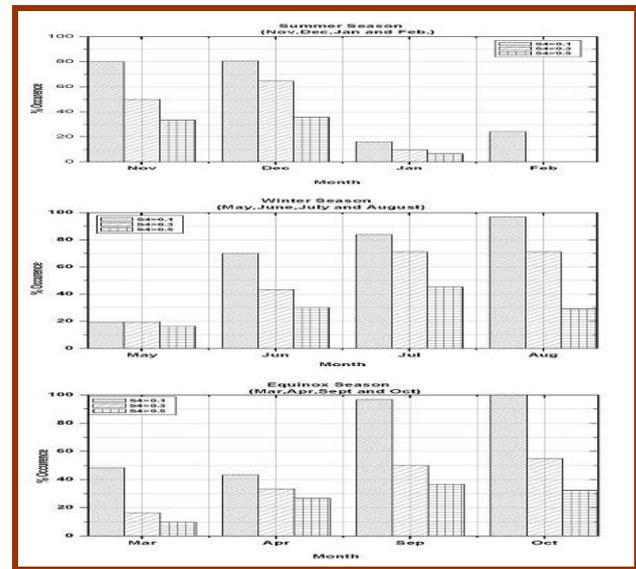
**Figure 1:** The Percentage Occurrence of S4 Index at Universal Time In a Year



**Figure 2:** Seasonal Percentage Occurrence Of S4 Index

The high latitude scintillations, in general, occur over night side auroral oval and over the polar cap virtually at all local times. In winter moderate L-Band scintillations are observed in association with the so-called polar cap patches<sup>6</sup>. When the Interplanetary Magnetic Field (IMF) is directed southward, patches with high ionization density are observed to enter the polar cap from the day side auroral oval, convected in the anti – sunward direction and eventually exit into the night side auroral oval. One mechanism by which patch formation is achieved corresponds to changing the plasma convection pattern in response to the IMF By component during periods of southward Bz<sup>7</sup>. Among several other formation mechanisms, one of these considers the role

of large plasma flows in the formation of discrete patches has been experimentally substantiated<sup>8,9</sup>. The role of large plasma flows in the formation of discrete patches has been experimentally substantiated.



**Figure 3:** Seasonal Wise Monthly Percentage Occurrence of S4 Index

#### IV. CONCLUSION

- The scintillations observed during the year 2008 were generally weak type ( $S4 < 0.1$ ). However, during morning and afternoon hours, slightly higher magnitude scintillations ( $S4 < 0.5$ ) were also found to occur.
- During the seasonal study of scintillation occurrence the maximum L band scintillation occurrence is observed during the summer seasons.
- The maximum percentage occurrence is observed between the month of June and December 2008.

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