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The statistical investigation of amplitude Scintillations at Indian high latitude Station Maitri, Antarctica

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Abstract. We have investigated the occurrence characteristics of ionospheric scintillations, using dual frequency GPS receiver, installed and operated at Indian scientific base station Maitri (71.45S and 11.45E) Antarctica, during December 2009 to December 2010. The scintillation morphology is described in terms of S4 Index. The scintillations are classified into four main categories as Weak ($0.2 < S4 < 0.4$), Moderate ($0.4 < S4 < 0.6$), Strong ($0.6 < S4 < 1.0$) and Saturated ($S4 > 1.0$). From the analysis we found that the percentage of weak, moderate, strong and saturated scintillations were 96%, 80%, 58% and 7% respectively. The maximum percentage of all types of scintillation was observed in the summer season, followed by equinox and the least in winter season. As the year 2010 was a low solar activity period, consequently the maximum occurrences of scintillations were those of weak and moderate and only four cases of saturated scintillation were observed.

1. Introduction

The structure of the auroal and high latitude ionosphere is very complicated and varied. Dramatic changes take place very frequently in the auroral and polar regions. In this region, irregularities at different scale are quite common, which cause phase and amplitude fluctuations in the trans-ionospheric signals as these signals encounter the irregularities. The amplitude and phase fluctuations of radio signals are commonly referred to as scintillations. The ionospheric scintillation is a very important parameter for describing the morphological features of ionosphere. The ionospheric disturbances or irregularities produce significant effects on satellite signals used for communication and navigation; hence disturb communication and navigation applications. Therefore scintillation studies involving trans-ionospheric propagation is of considerable interest in understanding the physical processes controlling high latitude ionospheric dynamics viz. generation and transport mechanisms of ionospheric irregularities, soft particle precipitation with energies approximately 100eV, penetration of magnetospheric electric fields and auroral current systems [1].

A number of studies, concerning the GPS scintillations at high latitudes, have been conducted in the recent past [2, 3]. Using GPS observations from 11 high-latitude stations, Aarons [4] noted that phase fluctuation activity has a daily pattern mainly controlled by the motion of the receiver location into the auroral oval. De Franceschi et al. [5] using the observations from a chain of GPS ionospheric scintillation and TEC receivers in Northern Europe during the storm events of 30



October and 20 November 2003 found a strong influence of IMF on the formation and movement of plasma patches.

Many researchers have studied the morphology of L band GPS scintillation [6, 7, 8] in terms of S4 and $\sigma\phi$ indices. Their morphological studies have shown that amplitude scintillation activity produced due to ionospheric irregularities varies with 11 year solar cycle, geomagnetic activity, geographical location, seasons as well as local time of the day.

The present study is carried out to statistically examine the diurnal and seasonal variations of scintillation at high latitude station Maitri, Antarctica during the low solar activity period 2010.

2. Data and method of analysis

To study the occurrence characteristics of high latitude L-band GPS scintillations, we have used the data recorded by NovAtel's dual frequency GPS receiver GSV4004A installed and operated at Indian Antarctic station Maitri, during December 2009 to December 2010. 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 cutoff of elevation angle was set to 40 degree. 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 corrected S4, with the effects of ambient noise removed, is computed as

$$S_4 = \sqrt{(S_{4T}^2 - S_{4No}^2)}$$

Where S_{4T} is total S4 and S_{4No} is correction due to ambient noise over 60s intervals.

3. Results and discussion

The S4 scintillation index is the normalized variance of the intensity and is a commonly accepted measure of signal fluctuation caused by ionosphere irregularities. Figure 1 shows the diurnal variation of scintillation occurrence in the auroral region during December 2009 to December 2010. The twelve different panels show the occurrence of scintillations diurnally during all the twelve month of the year 2010. In the figure S4 index is plotted against the Universal Time. The different colors represent the different days of month. The different thresholds of S4 index were chosen to categorize the intensity level of scintillations. From the figure we find that all the four types of scintillation viz. weak, moderate, strong and saturated are observable. However, during the months of June and July 2010, very low level of scintillations were observed with only few cases of strong and moderate scintillations. The strong scintillation activity was observed during the months of November, December, February and March 2010. Only four cases of saturated condition were observed which occurred in the month of November, December, January and February. Figure 2 describes the percentage of scintillation observed during three different seasons of the year 2010. From the Figure 2 we find that maximum percentage of all types of scintillations is observed during summer season followed by equinox season and the least during winter season. The percentage of weak, moderate, strong and saturated scintillations was observed to be 96%, 80%, 58% and 7% respectively. The only four cases of saturated scintillation were observed during summer season.

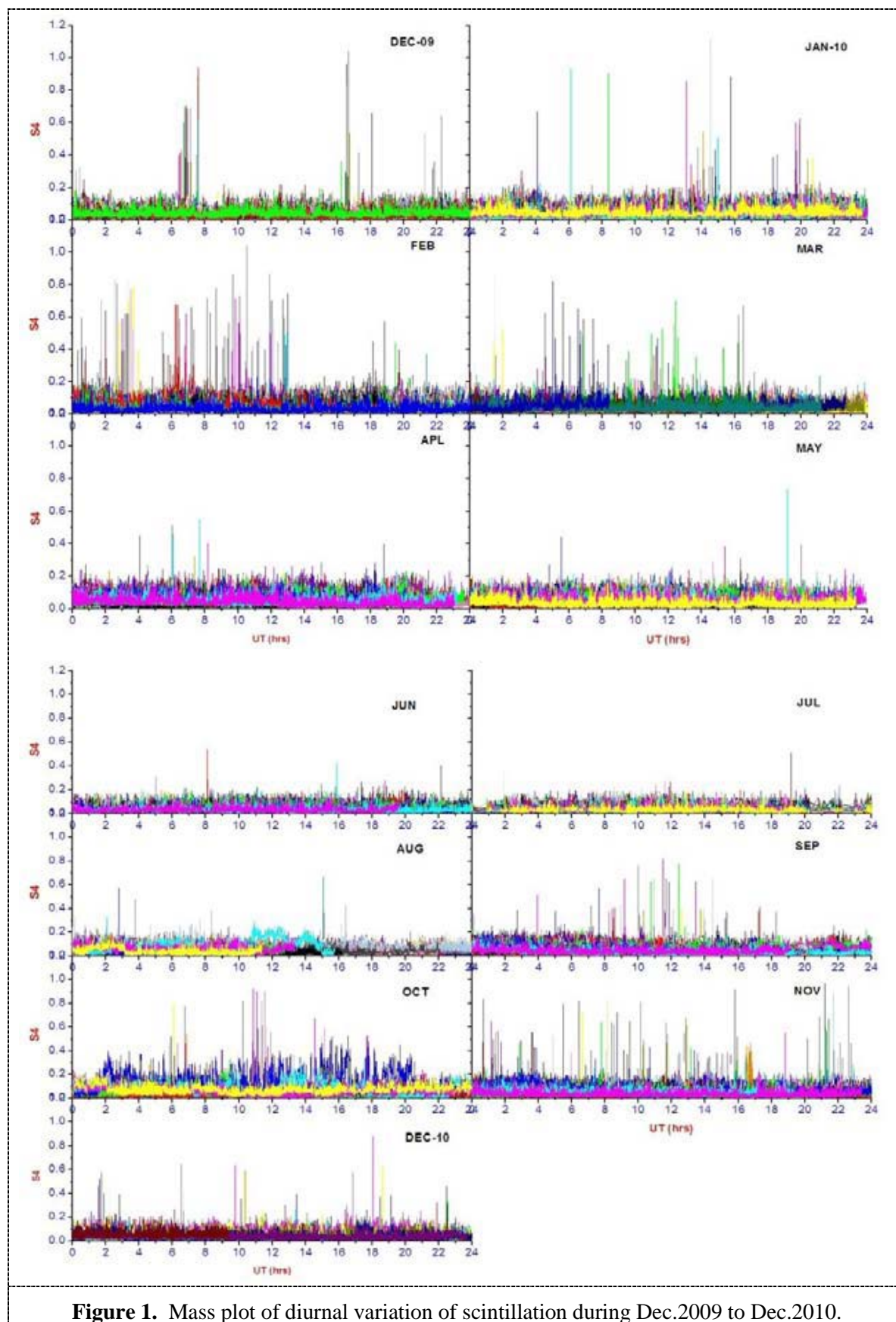
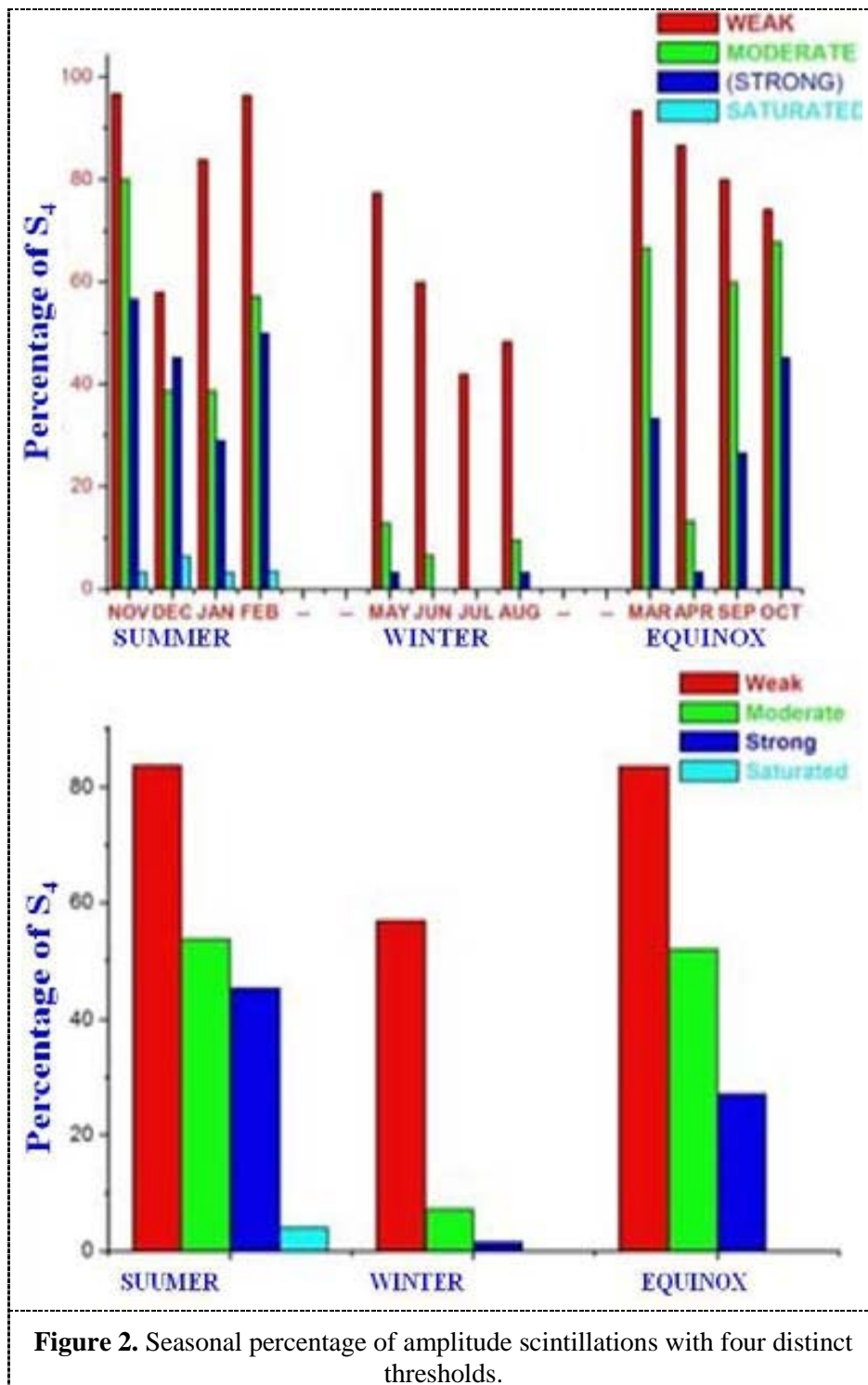


Figure 1. Mass plot of diurnal variation of scintillation during Dec.2009 to Dec.2010.



4. Conclusions

From our analysis to statistically examine the occurrence characteristics of GPS scintillation at high latitude station, Miatri during the low solar activity period 2010, we conclude our findings as follows: The percentage of weak, moderate, strong and saturated scintillations were 96%, 80%, 58% and 7% respectively. Thus, the maximum percentage was those of weak and moderate scintillations. Only four cases of saturated scintillation were observed during the observational period. The maximum

occurrences of all types of scintillations were observed in summer season followed by equinox season and the least in winter season. In terms of monthly occurrences the maximum occurrence of scintillations was observed during the months of October, November, February and March.

5. Acknowledgements

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