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Some results of night-time scintillations at low latitude

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Abstract. Ionospheric scintillation observations of VHF radio signals from FLEETSAT satellite (73°E longitude) at Bhopal from January 1990 to December 1990 have been used to study the characteristic variations of scintillation activity. It is found that scintillation occurrence is essentially a night-time phenomenon and day-time scintillations are very rare. Annual average nocturnal variation of percentage occurrence of scintillations shows maximum at around 2100–2200 hours LT. Seasonally, scintillations are most prominent during equinoxes and least during summer. Geomagnetic disturbances tend to decrease the occurrence of scintillations in the pre-midnight period.

Keywords. Ionospheric scintillation; percentage occurrence; F-region irregularities; geomagnetic disturbances.

1. Introduction

Ionospheric scintillation was initially observed on the amplitude recording of signals from discrete radio sources in the sky and the phenomenon was suggested to be associated with spread-F (Wild and Roberts 1956; Koster 1958; Bhargava 1964). The F-region irregularities generally associated with spread-F have been considered to be the main cause of intense night-time scintillations (Huang 1970; Chandra and Rastogi 1974; Chandra *et al* 1979; Rastogi 1982; Dabas and Reddy 1986; MacDougall 1990). Scintillations of trans-ionospheric signals for very high frequency (VHF) range have been studied at equatorial and low latitudes (Rastogi *et al* 1977; Huang 1978; Krishnamoorthy *et al* 1979; Aarons 1982; Rastogi *et al* 1982; Rastogi 1983; Vijay Kumar *et al* 1988; Pathan *et al* 1991; Rastogi *et al* 1991). In the recent observations of scintillations at Bombay (19°N, 73°E), Koparkar and Rastogi (1985) and Koparkar (1987) have shown the peak of occurrence of scintillations at about 2200 hours.

Koster and Wright (1960) have shown that during high solar activity there was marked negative correlation between occurrence of scintillations and degree of geomagnetic disturbances during any period of night. Effect of geomagnetic disturbances on scintillations have been discussed at Thumba (Chandra and Rastogi 1974), Ootacamund (Chandra *et al* 1979) Huancayo (Rastogi *et al* 1981), Calcutta (DasGupta *et al* 1985), Bombay (Koparkar and Rastogi 1986; Koparkar 1987) and Delhi, Calcutta, Lunping and Manila (Dabas *et al* 1989). In the present study, we will concentrate on the observations and preliminary results at Bhopal (23·7°N, 77·2°E) which is located latitudinally almost in the middle of Bombay (19°N, 73°E) and Delhi (28·6°N, 77·2°E). Further, an attempt has been made to examine the effect of geomagnetic disturbances on scintillations.

2. Observational details and analysis

Radio wave scintillations are being recorded with the system capable of receiving the signals at a frequency of 244 MHz from the geostationary satellite, FLEETSAT, located at equator (73°E long.). A simple eleven element Yagi-Uda antenna and indigenously made VHF-receiver have been used for receiving the signals. A single channel chart recorder has been used for recording the amplitude of signals. Peak-to-peak amplitude fluctuations of $\geqslant$ 1dB (Rastogi *et al* 1990) corresponding to scintillation index ($\geqslant 10\%$) have been considered the basis of the data. Scintillation Index, (SI) defined by the following equation, as proposed by Whitney *et al* (1969) is used to represent the depth of scintillations:

$$\mathrm{SI(dB)} = P_{\max} - P_{\min}$$

where $P_{\max}$ is the power amplitude of the third peak down from the maximum excursion and $P_{\min}$ is the power amplitude of the third peak up from the minimum excursion.

3. Results and discussion

Scintillation activity at Bhopal is generally found to start abruptly, reaching peak to peak amplitude of 10–20 dB within few minutes. In the pre-midnight period fading rate is high (10–15 fades/min) and the depth of fading is deep (SI > 7·5 dB). In the post-midnight period the fading rate is low (4–10 fades/min) and the depth of fading is moderate (SI < 5·0 dB). On some occasions, the scintillation index is weak (SI < 2·5 dB) in the beginning, with lower fading rate and later develops into strong scintillations with higher fading rate. Chandra *et al* (1979) have shown that range type of spread-F is associated with strong radio wave scintillations observed at all the frequencies whereas frequency type of spread-F is associated with weak scintillations on 40 MHz only. Krishnamoorthy *et al* (1979), have classified the ionospheric scintillations into two classes (class I & class II), depending upon the fading rates and their association with bottomside spread-F. Vijay Kumar *et al* (1988) have classified the ionospheric scintillations into class I (10–15 fades/min) and class II (3–5 fades/min) depending upon the fading rates. Scintillations at Bhopal may be separated into those occurring in pre-midnight period and to those occurring in post-midnight period. Sometimes, the nature of scintillations occurring in pre-midnight period is found to be similar to the scintillations occurring in post-midnight period and vice versa also. Scintillations occurring in pre- and post-midnight periods may be caused by type A and type B irregularities proposed by Krishnamoorthy *et al* (1979). Sample records of scintillations received at Bhopal are shown in figure 1.

The nocturnal variations of percentage occurrence of scintillations during three seasons: equinox (March, April, September, October), winter (January, February, November, December) and summer (May, June, July, August) are shown in figure 2. The peak of occurrences are seen to be at around 2100 hours during equinoxes and winter while during summer the peak of occurrence is seen at around 0200 hours. Scintillations are more frequent during equinoxes with a magnitude of peak occurrence about 17% and least during summer with the magnitude of peak occurrence about 7%. Basic features of scintillations at Ootacamund, reported by Chandra *et al* (1979)

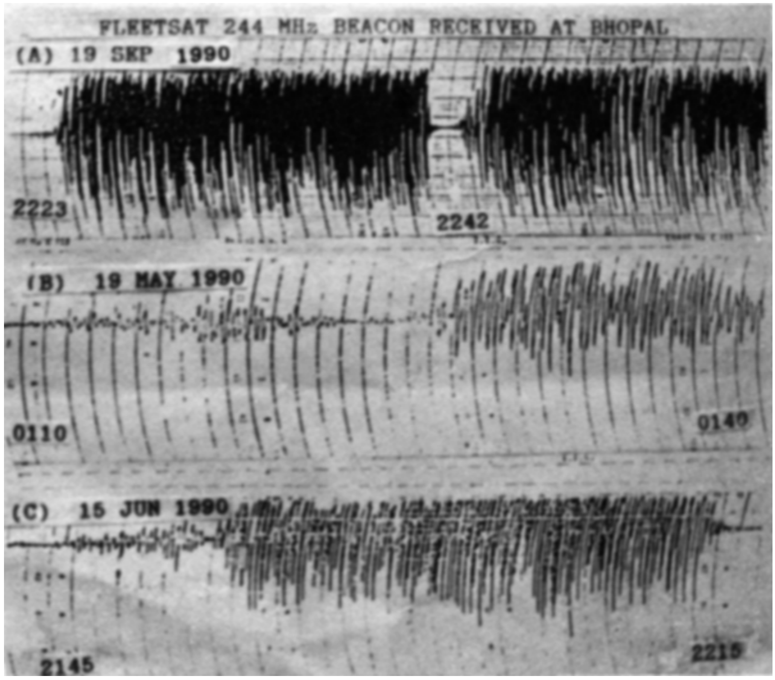

Figure 1. Sample records of VHF scintillation recorded at Bhopal at 244 MHz from FLEETSAT.

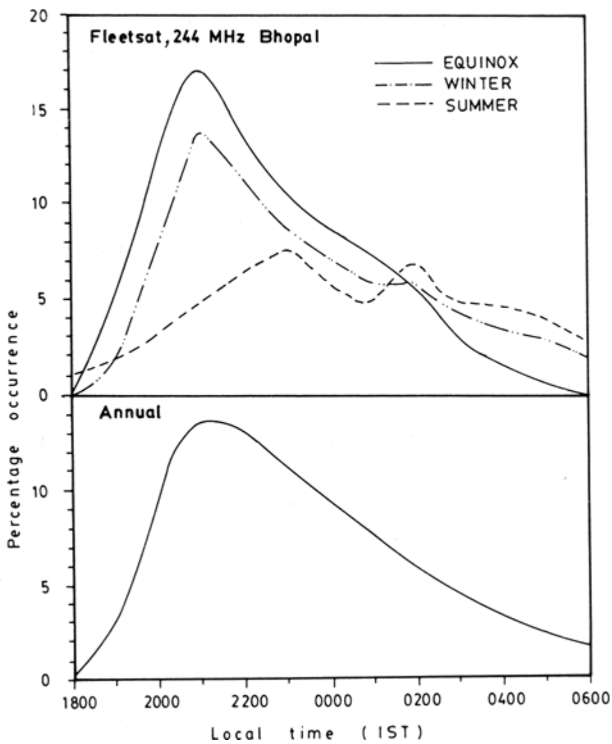

Figure 2. Nocturnal and seasonal variations of percentage occurrence of scintillations at Bhopal.

and later on by Rastogi *et al* (1982) showed the equinoxial maxima. Koparkar (1987) using the amplitude scintillation data from 1982 to 1984 at Bombay showed that scintillations are more frequent during equinoxes and less during summer with peak of occurrences at around 2200 hours. Chandra *et al* (1989) have shown the maximum occurrence of scintillations during equinoxes for low latitude station, Tiruchirapalli, in the Indian region. Rastogi *et al* (1991) have shown the scintillation occurrence to be largest during equinoxial months and least during summer months for Indian equatorial stations. For American stations, they found the largest occurrence of scintillations during winter months and least during summer months. Night-time annual variation of percentage occurrence of scintillations depicted in the lower part of figure 2, shows the peak of occurrence at around 2100–2200 hours. This is not very different from the results obtained for the equatorial and low latitude stations (Chandra and Rastogi 1974; Aarons 1977; Yeh *et al* 1981; Pathan *et al* 1991; Chandra *et al* 1992). Figure 3 shows the plot of scintillation patches occurred in pre-and post-midnight periods of each month. The scintillation patches are more frequent in the pre-midnight period from January to April and July to December while during May and June scintillation, patches are more frequent in the post-midnight period.

To study the effect of geomagnetic disturbances on scintillations, the percentage occurrence of scintillations has been separated into two groups of five international quiet (Q) days and five international disturbed (D) days. This method ensures the equal weight for two sets of days. Out of 60 days in a year of each set of Q and D days, the observations are available on 51 days for Q days and 48 days on D days. The variations of percentage occurrence of scintillations on Q and D days for different seasons are shown in figure 4, it is seen from this figure that during the geomagnetic disturbances the scintillations are reduced in the pre-midnight period and increased in the post-midnight period during equinoxes and winter. But during the summer scintillations are increased in the pre-midnight period and reduced in the post-midnight period. Rastogi and Woodman (1978b) have shown that if during any

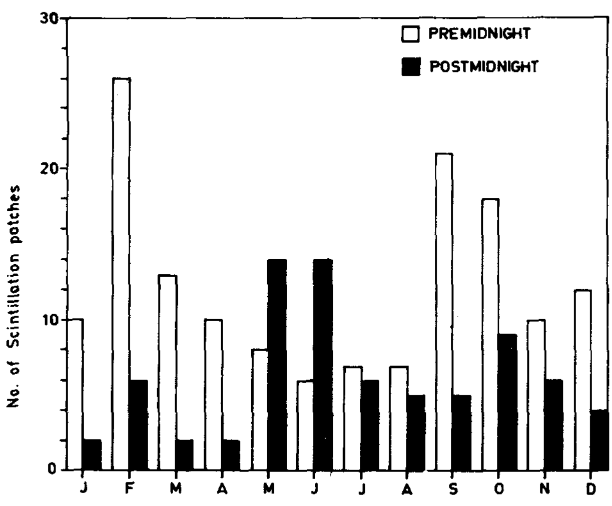

Figure 3. Month to month variation of pre-midnight and post-midnight scintillation patches during Jan.–Dec. 1990.

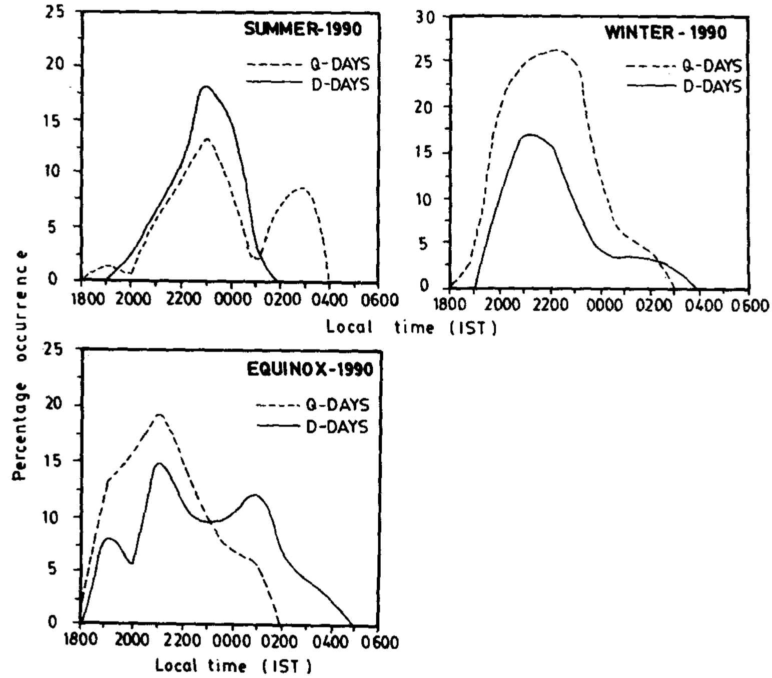

Figure 4. Nocturnal variation of percentage occurrence of scintillation on five International Quiet (Q) and five International Disturbed (D) days during summer, winter and equinox months.

part of night the F-region vertical drift reverses from downward to upward, then range type spread-F is generated in an hour. This reversal is, in general, associated with geomagnetic disturbances. Rastogi and Aarons (1980) have shown the cases of generation of F-region irregularities near the magnetic equator following a reversal of F-region vertical drift from normal downward to an upward direction. Such a reversal of vertical drift requires an eastward field, contrary to normal westward field. During magnetic disturbances, the reversal of electric field from westward to an eastward direction is possible because of coupling of high latitude and magnetospheric current systems with equatorial and low latitude electric fields.

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