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Ionospheric scintillations by sporadic-E irregularities over low latitude

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Abstract. The observations of daytime ionospheric scintillation are attributed to E-region irregularities at high and equatorial latitudes. In this paper, VHF amplitude scintillations recorded during the daytime period from 1991 to 1999 at low latitude station Varanasi (geomag. lat. = 14° 55′ N, long. = 154^0 E) are analyzed to study the behaviour of sporadic-E irregularities during the active solar and magnetic periods. The daytime digital scintillation data have been analyzed to study some important parameters of scintillation producing sporadic-E irregularities like auto-correlation function, power spectral densities, signal de-correlation time etc. We report the behaviour of these parameters under weak and strong scintillation conditions. The results are also discussed in the light of recent works.

Keywords : ionospheric irregularities – VHF scintillations – sporadic-E – wave propagation.

1. Introduction

Ionospheric scintillation of radio waves are mainly a nighttime phenomenon associated with occurrence of spread-F in the path of radio waves. Daytime scintillations are attributed to E-region irregularities (Anastassiadis et al. 1970; Rastogi & Iyer 1976; Das-Gupta & Kersley 1976). Aarons & Whitney (1968) considered the daytime scintillations

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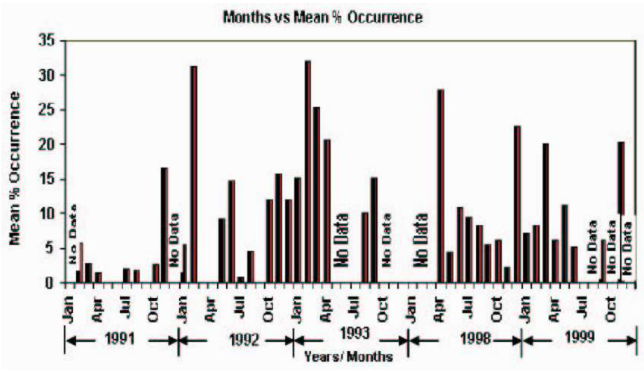

Figure 1. Monthly mean percentage occurrence of daytime scintillation from 1991-1999 observed at Varanasi.

observed at Sangamore hill (dip 73° N) to be due to E_s cloud and estimated the horizontal dimension to be 300-600 km. After simultaneous observation of vertical ionospheric soundings and the Faraday fading of the beacon from a low orbiting satellite, Rastogi & Iyer (1976) showed the existence of a cloud of intense sporadic-E in the path of radio waves, which produced scintillations even during the daytime at low latitudes.

In this paper VHF amplitude scintillations recorded during the daytime period from 1991 to 1999 at the low latitude station Varanasi are analyzed to study the behaviour of sporadic-E irregularities during the active solar and magnetic periods.

2. Results and discussions

The month-to-month variation of the mean percentage occurrence of daytime scintillations for the year 1991-1993 and 1998-1999 is shown in Fig. 1. In general, the occurrence of daytime scintillation activity is maximum in winter months, moderate in equinox and minimum in summer months. The fading rate is generally observed slow for the daytime scintillations.

The temporal scale length of the irregularity is the distance at which auto-correlation function falls to 0.5 (Khastgir & Singh 1960). Few typical examples of auto-correlation functions derived from daytime scintillation data recorded on (a) 2 March, 1993 at 1517-1520 hr IST (b) 9 April, 1993 at 1502-1505 Hrs IST are shown in Fig. 2(a) and Fig. 3(a). According to Fig. 2(a), the half de-correlation time τ for three different cases are $\tau_1 = 7.1$ sec, $\tau_2 = 6.0$ sec, $\tau_3 = 7.7$ sec. Considering the minimum and maximum drift velocities of irregularities observed over Varanasi as 75 m s^{-1} and 200 m s^{-1} (Singh et al. 2006), we have estimated minimum and maximum range of temporal scale length of sporadic-E irregularities. We have computed temporal scale length of 50 samples and found that it varies between 200 m and 700 m for the minimum drift velocity of 75 m s^{-1} and for

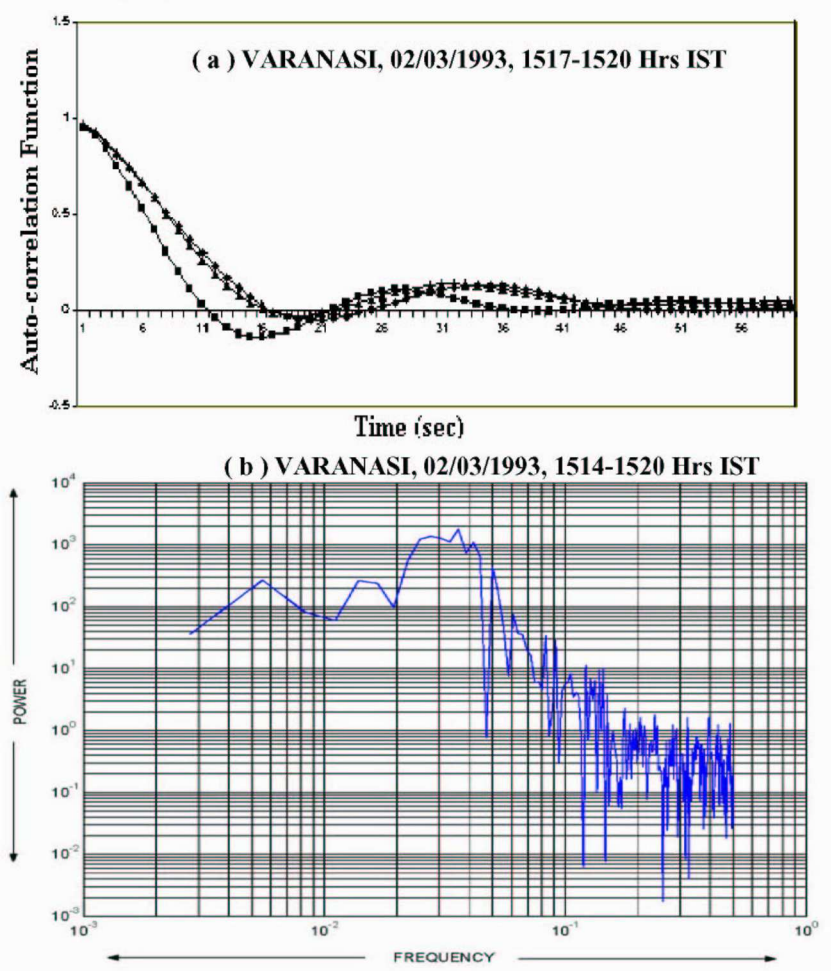

Figure 2. Typical example of (a) auto-correlation function and corresponding (b) power spectra of daytime scintillation observed at Varanasi on 2 March 1993 at 1514-1520 hr.

the maximum drift velocity, the temporal scale length varies between 600 m and 1900 m, which corresponds to intermediate scale length.

We have carried out the analysis of 25 samples of daytime scintillation data and estimated power spectra, which contains information about relative power of irregularities in frequency. Two typical examples of the power spectra derived from the daytime scintillation data recorded on the same day and time of above auto-correlation function on (a) 2 March, 1993 at 1514-1520 hr IST (b) 9 April, 1993 at 1459-1505 Hrs IST are shown in Fig. 2(b) and Fig. 3(b) respectively. The slopes of spectra in the frequency range 0.1

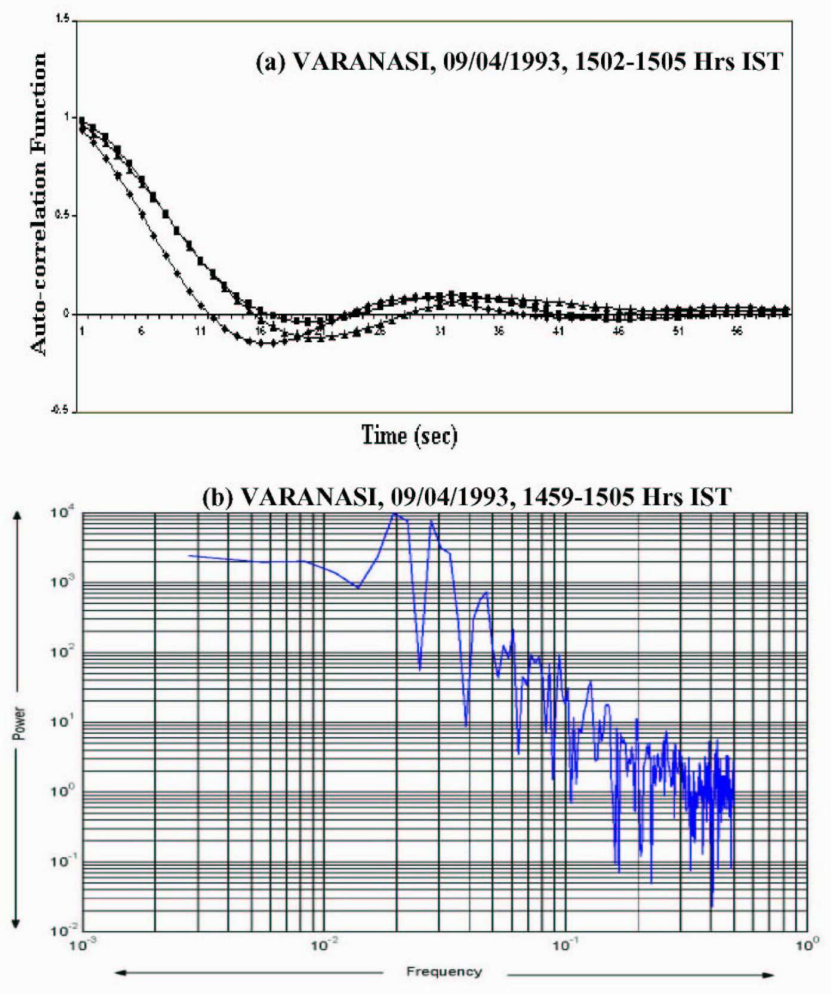

Figure 3. Typical example of (a) auto-correlation function and corresponding (b) power spectra of daytime scintillation observed at Varanasi on 9 April 1993 at 1459-1505 hr.

Hz $\leq$ f $\leq$ 0.5 Hz are -4.8 and -7.5 respectively. We have computed spectral slopes of all 25 samples and found that the spectral index ranges between -2 and -9.

The variation of half de-correlation time (τ) with S_4 index is shown in Fig. 4, which shows a scattered plot of τ with S_4. The scattered plot of τ with S_4 at our station may be apparent because of limited observations obtained at daytime. The computed scintillation index varies between 0.4 and 0.8. This shows that the daytime scintillations observed over Varanasi are of moderate type. Further Fig. 4 clearly shows that the half

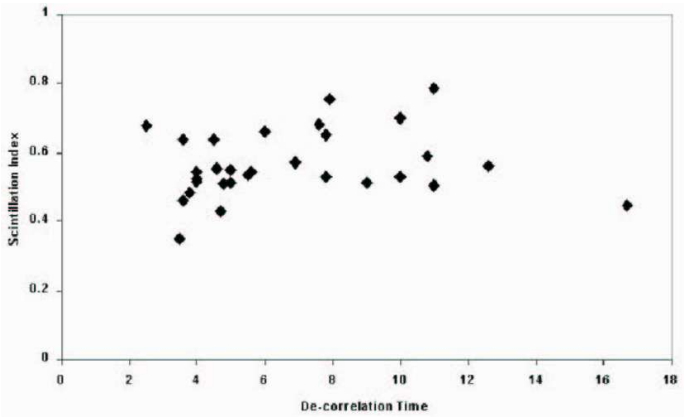

Figure 4. Variation of scintillation index S_4 with half de-correlation time.

de-correlation time is almost independent of scintillation index. This may be due to the fact that the de- correlation time is controlled by the Fresnal scale size and not by the perturbation level.

3. Summary

Since the observation of daytime ionospheric scintillations are attributed to E-region irregularities, the detailed analysis of daytime VHF scintillations observed at low latitude Varanasi yields the information about the sporadic-E region irregularities over low latitude. The characteristic features of these irregularities derived from the present study are summarized below:

1. The occurrence rate of daytime scintillation shows that in general the sporadic-E irregularity is maximum during winter months and moderate during equinox months and minimum during summer months. The fading rate is generally slow.

2. The spectral index of overhead sporadic-E irregularities generally range between -2 and -9.

3. Since the estimated temporal scale length of the sporadic-E irregularities depends upon the velocity, we obtained a minimum range (200 m – 700 m) and a maximum range (600 m – 1900 m) for the temporal scale length of irregularities observed over Varanasi. The irregularities belong to intermediate scale length.

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