Indian Journal of Radio & Space Physics
Vol. 25, June 1996, pp. 163-167

# Daytime amplitude scintillations at a low latitude station, Calcutta

S K Das, S K Chakraborty* & A DasGupta
Institute of Radiophysics and Electronics, University of Calcutta, Calcutta 700 009

Received 20 March 1995; revised 19 July 1995; accepted 30 November 1995

The paper deals with ionospheric scintillations of the 136 MHz signal from the geostationary satellite ETS-II observed during daytime at Calcutta (23°N; 88.5°E; 32°N dip) which is situated well outside the equatorial electrojet region. Observations over a solar cycle (1977-1986) show that daytime scintillation is essentially a local summer (May-July) phenomenon. There is no systematic variation of daytime scintillation occurrence with sunspot number. Simultaneous record of Faraday polarization angle of the satellite signal shows that all the cases of daytime scintillations occur when there are definite signatures of travelling ionospheric disturbances (TIDs) which are manifestations of atmospheric gravity waves. However, the reverse is not true. There are days when the Faraday rotation record exhibited periodic structures but no scintillation in amplitude was observed.

## 1 Introduction

The diurnal variation of scintillations shows two maxima with the principal occurrence during nighttime along with a secondary peak around noon[1-5]. Though the nighttime scintillation of trans-ionospheric signals has been one of the most intensively studied phenomena, the daytime scintillations have not received much attention mainly because of their mild nature and relatively less frequent occurrence. The correlation between daytime scintillations and sporadic-E has been suggested by many, but studies on the association of the two phenomena based on long-term observations and data have been very few. Aarons and Whintey[3] suggested that a value of $f_0$Es $\geqslant 5$ MHz is one of the important parameters responsible for the daytime scintillations and that disturbances at heights above Es may play a role in the production of daytime scintillations. Anastassiadis *et al.*[6] found that scintillation at midlatitude is closely associated with disturbances above the sporadic-E layer. Rastogi and Iyer[7] observed that signals from low orbiting satellites showed strong scintillations only during the portions of transits when the path traversed a region of strong sporadic-E as seen from vertical incidence ionogram. Analyzing two years' scintillation data obtained at the temperate latitude location of Aberystwyth, Wales, during the declining phase of solar activity (1972-1973), DasGupta and Kersley[5] have shown that the VHF scintillation occurence is linked with a high critical frequency and range spread of Es on ionogram. It has also been suggested that short period gravity waves may be one of the possible mechanisms for producing an extended vertical structure of Es.

The results of some observations of daytime scintillations at Haringhata which is situated in the transition zone from the low to the temperate latitude, as far as the sporadic-E region of ionosphere is concerned, is presented in the present paper. To the best of knowledge the long-term morphology of daytime scintillations has not yet been reported from any location. The present study covers a period of nearly one solar cycle from 1977 through 1986.

## 2 Data

Amplitude and Faraday polarization of the 136 MHz transmission from the geostationary satellite ETS-II have been monitored at Haringhata during 1977-1990. Data for the period 1977-1986, covering about one solar cycle, have been used in the present case. The satellite beacon records were continuous, excepting for the satellite eclipses around midnight during the equinoxes after 1980 and for periods of power failures and equipment malfunctions. The amplitude records have been calibrated at 1 dB interval at least once a week. The satellite steady-signal level is adjusted about 6 dB down from the saturation level and the dynamic range of the recording system was in the 20-25 dB range. Amplitude scintillation records were scaled according to the usual third peak method.

Scintillations occurring at this location during daytime are generally weak to moderate in nature. On

*Present address: Department of Physics, Tripura University, Agartala 799 004.

a few occasions, of course, intense scintillations exceeding 10 dB are also observed. Scintillating irregularities normally sweep past the antenna beam in patches; a series of more than five patches is not uncommon when daytime scintillations are recorded during some seasons (particularly in the local summer). The fading pattern often shows regular and quasi-periodic features during the onset and decay of scintillations. Cases of intense equatorial type scintillation associated with magnetic disturbances are, sometimes, recorded at Calcutta in the postsunrise period[8]. Such cases of disturbance-induced scintillations in the postsunrise hours are excluded from the present study.

Figure 1 shows a case of intense daytime scintillations recorded at Haringhata. The upper trace shows the Faraday rotation of the signal observed simultaneously.

## 3 Seasonal and solar activity dependence

Figure 2 shows monthly mean percentage occurrence of daytime scintillations with SI > 1 dB during the period April 1977 through December 1986. It may be seen that daytime scintillation is essentially a local summer (May-July) phenomenon. The distinct summer maximum is consistent throughout the solar cycle. As far as long-term variation of this summer phenomenon is concerned, no definite pattern of variation with sunspot numbers over the solar cycle (1976-1986) could be obtained. Scintillation activity is high in 1977 for sunspot number $R_z = 27.6$ and in 1978 for $R_z = 92.5$. On the other hand, the occurrence is very low in 1985 when $R_z = 17.9$.

The absence of a clearcut solar activity dependence of daytime scintillation at the present location is contrary to that observed with sporadic-E at low and temperate latitudes. Sporadic-E at low and temperate latitudes is related to the location of the station with respect to the magnetic equator vis-a-vis geographic equator[9-11]. There may be a large variation in the behaviour of daytime scintillations even within the low latitude zone, possibly with a longitudinal modulation also.

## 4 Variation with local time

As has been observed, the daytime scintillation is essentially a May-July phenomenon at this location, with little or no occurrence in other seasons. For studying the occurrence of daytime scintillations as a function of local time, data for these months are considered. Figure 3 shows the hourly percentage occurrence of daytime scintillations obtained at the present location during May-July of the years 1977 through 1986. The variation shows a clear peak around noontime throughout the solar cycle. The noontime peak is more prominent in solar maximum years. Sometimes a less prominent peak is observed in the prenoon hours, particularly at low solar activity level. There is

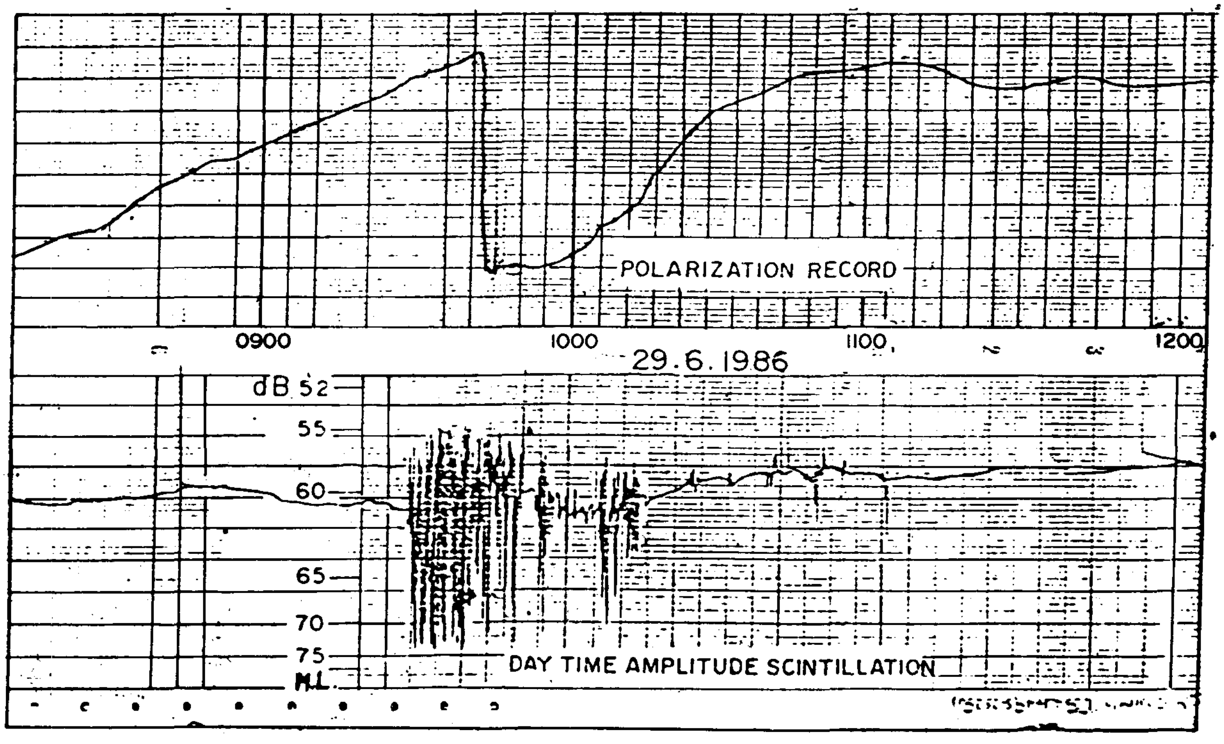


Fig. 1—Simultaneous records of daytime intense scintillations and Faraday rotation with signatures of TIDs

also a signature of an afternoon secondary peak in some years.

From a comparison with the sporadic-E occurrence at a similar location, e.g. Ahmedabad (23°N; 72.4°E; 34°N dip), no particular relationship of scintillation occurrence with $f_0$ Es could be suggested. For two years of relatively high scintillation activity (1977 and 1978) the percentage occurrence of $f_0$Es $\geq 7$ MHz at Ahmedabad is found to be about 4, whereas for much lower scintillation activity for the years 1983 and 1986 the mean percentage occurrence of $f_0$Es $\geq 7$ MHz is about 18. It should be mentioned that there is a significant longitude displacement of the ionosonde station.

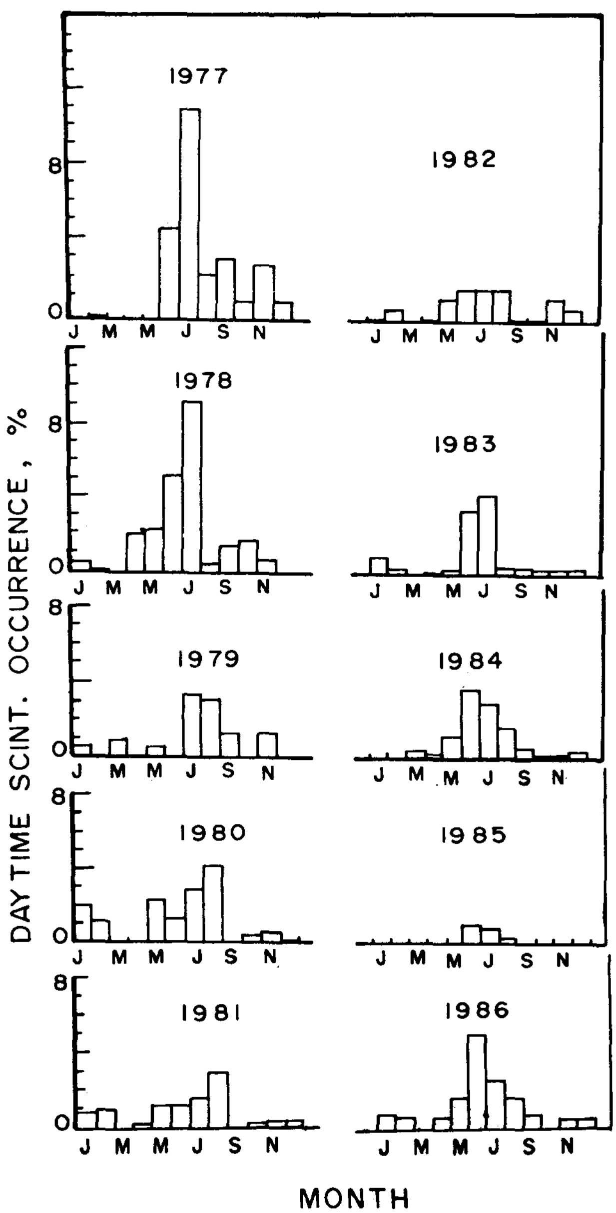


Fig. 2—Monthly mean occurrence of daytime scintillations (SI $\geq$ 1 dB) during May 1977 through 1986 at Calcutta

Moreover, the ionosonde data are insufficient, as four (1979, 1982, 1984 and 1985) of the total ten years data (1977-1986) are missing.

## 5 Daytime scintillation and travelling ionospheric disturbances (TIDs)

In examining the factors which might influence the vertical structure of the sporadic-E layer, simultaneous Faraday rotation records obtained from the same satellite as the scintillation recordings were analyzed for evidence of quasi-periodic fine structures which are supposed to be ionospheric manifestations of internal gravity waves at F-region heights. On the contrary, daytime scintillations are believed to be of sporadic-E origin. Faraday rotation records have been examined for evidence of wave perturbations, using a 2 h section of records starting at the observed time of scintillation onset[5]. A time lag of up to two hours has been chosen to allow for the propagation of disturbance from Es to F-region heights[12].

To verify the association between daytime scintillations and TIDs, the years 1978 and 1986 are selected. Solar activity during 1978 was pretty high, almost comparable to the maximum of the previous cycle. The year 1986 corresponds to the solar minimum phase. Daytime as well as nighttime scintillations during May-July of these two years were quite frequent. Simultaneous Faraday rotation records were examined for the presence of periodic structures. A section of Faraday rotation record as shown in Fig. 1, clearly exhibits signatures of periodic structures. Out of 67 days of uninterrupted records during May-July of 1978, there were 27 days when both TIDs and daytime scintillations were present. On the other hand, on 21 occasions, TIDs were observed, but no scintillations were recorded. There were no scintillations and no TIDs for the remaining days. No case has been found when there was scintillation but no TIDs. In 1986 there were uninterrupted records for 81 days during the summer months (May-July). Out of 81 days, amplitude scintillations were observed on 37 days during daytime in presence of TIDs. On 33 days, there were no scintillations though Faraday rotation records exhibited TIDs. For the rest, there were no scintillations and no TIDs. Again, as in the year 1978, there was not a single event in which scintillations occurred with no traces of TIDs.

It should be emphasized that all the cases of daytime scintillations were associated with the presence of periodic structures in the Faraday rotation records but the reverse was not true, i.e. there were days when the Faraday rotation records exhibited periodic structures but no scintillations in amplitude were observed.

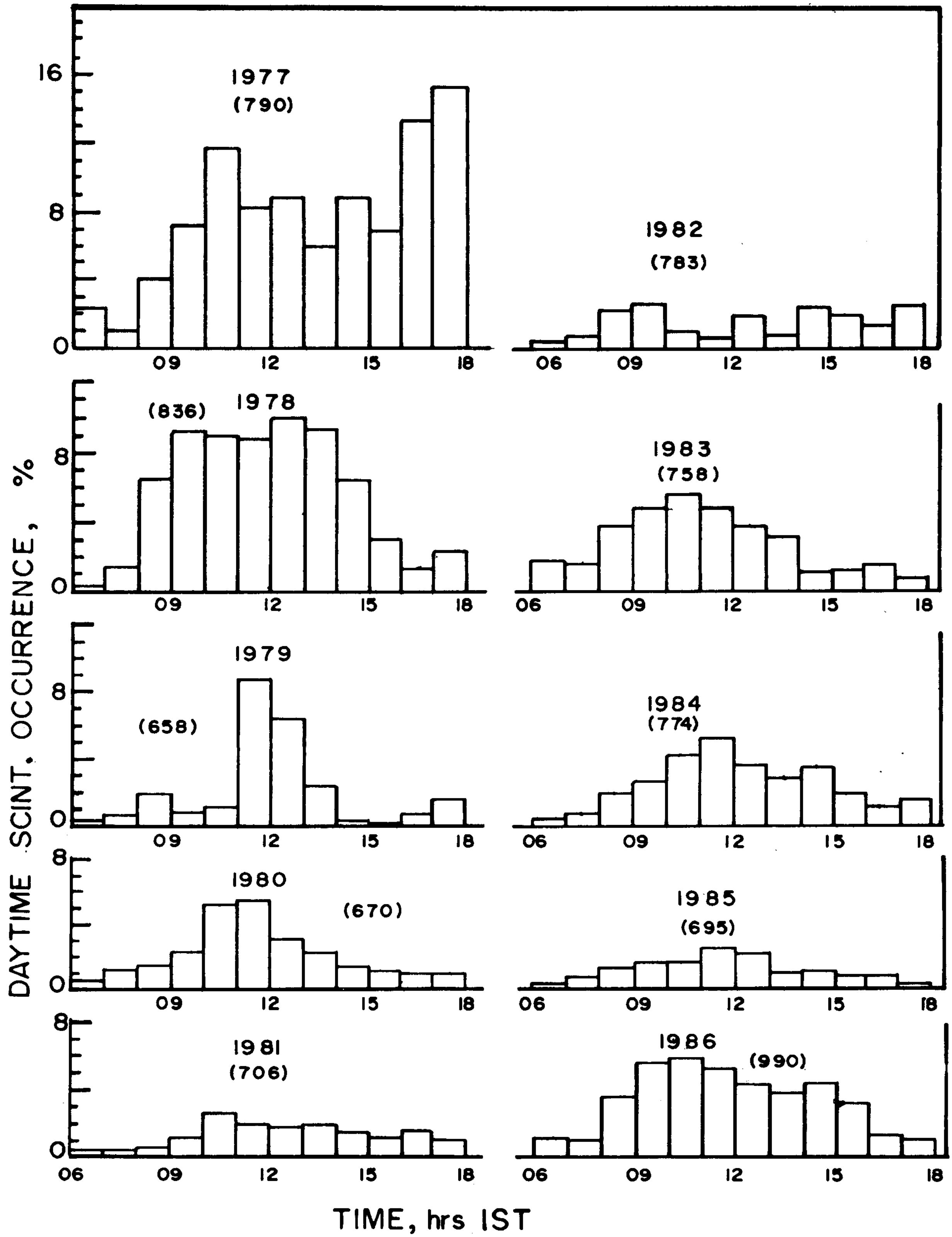


Fig. 3—Hourly occurrence of daytime scintillation during 1977-1986 (summer months) at Calcutta [The numbers in the brackets indicate the total hours of daytime records.]

## 6 Discussion

It has been observed that VHF transionospheric signals are, sometimes, subject to daytime scintillations, particularly, during the local summer (May-July) months. Although there is no supporting simultaneous ionosonde data, it is believed that the observed daytime scintillations in small patches with quasi-periodic fading patterns are mostly controlled by some characteristics of the sporadic-E region, in contrast to the severe nighttime scintillations which are identified with the equatorial F-region irregularities.

From the simultaneous Faraday fading and scintillation records from the same satellite at the present location, an association between daytime scintillations and TIDs has been shown. The TIDs, which are supposed to be ionospheric manifestations of atmospheric gravity waves at F-region height, have their possible origin in the meteorological sources like jet stream and other severe atmospheric disturbances[5,12,13]. Calcutta, which is situated in the temperate/midlatitude zone, has a seasonal occurrence pattern of daytime scintillations maximizing during the local summer months (May-July). Incidentally, this season is characterized by (i) intense meteorological activities like the local severe thunderstorms known as norwesters and the south-west tropical monsoon in the eastern part of the Indian subcontinent and (ii) Bay of Bengal.

There is compelling evidence that the daytime scintillations are associated with gravity waves. The gravity waves with short vertical wavelength may influence the vertical structure of the sporadic-E resulting in an extended or even stratified layer, giving rise to range spreading of sporadic-E on ionograms and scintillations of satellite signals[5]. It is, however, yet to be established whether the propagation of gravity waves from sources at meteorological heights to the F-region is compatible with windshears at E-region levels because of the possibility of filtering of at least some components of the gravity waves. It is also not known if the interaction of the gravity waves with wind shears would lead to the spreading or striations at E-region heights which is necessary for the daytime scintillation phenomenon. A complete reverse ray tracing programme with realistic atmospheric parameters may throw some light into this problem.

### Acknowledgements

The authors thank Dr. A Maitra for co-operation in recording the data. Helps extended by Drs S Basu, Sunanda Basu and J A Klobuchar in providing the VHF polarimeter and spares are gratefully acknowledged. This research is partly supported by the Department of Science and Technology, Government of India, through project ESS/75/18/89, and by the University Grants Commission, New Delhi, through project ECRA.

### References

1 Wild J P & Roberts J A, *Nature (UK)*, 178 (1956) 377.
2 Briggs B H, *J Atmos & Terr Phys (UK)*, 26 (1964) 1.
3 Aarons J & Whitney H E, *Planet &Space Sci (UK)*, 16 (1968) 21.
4 Aarons J, Whitney H E & Allen R S, *Proc IEEE (USA)*, 59 (1971) 159.
5 DasGupta A & Kersley L, *J Atmos & Terr Phys (UK)*, 38 (1976) 615.
6 Anastassiadis M, Matsoukas D & Moraitis G, *Radio Sci (USA)*, 5 (1970) 953.
7 Rastogi R G & Iyer K N, *Curr Sci (India)*, 45 (1976) 685.
8 DasGupta A, Maitra A & Das S K, *J Atmos & Terr Phys (UK)*, 47 (1985) 911.
9 Smith E K, *Ionospheric Sporadic-E*, edited by E K Smith & S Matsushita (Pergamon Press, Oxford), 1962, p. 1.
10 Leighton H I, Shapley A H & Smith E K, *Ionospheric Sporadic-E*, edited by E K Smith & S Matsushita (Pergamon Press, Oxford), 1962, p. 166.
11 Knecht R W & McDuffie R E, *Ionospheric Sporadic-E*, edited by E K Smith & S Matsushita (Pergamon Press, Oxford), 1962, p. 215.
12 Bertin F, Testud J & Kersley L, *Planet & Space Sci (UK)*, 23 (1975) 493.
13 Sengupta A, Nagpal O P & Setty C S G K, *Indian J Radio & Space Phys*, 6 (1977) 257.