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Ionospheric Scintillation at Legon

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Ionospheric scintillation observations made at Legon, Ghana (lat., 5.63° N; long., 0.19° E), during the year 1980 are reported for the geostationary satellite Marisat 1, transmitting at 257 MHz. Seasonal variation of scintillation index and depth of fade and the correlation between scintillation and geomagnetic activity are examined. The seasonal variation showed a pattern similar to the ones obtained previously at this station. The correlation coefficient between K_p sum (index) for magnetic activity and the scintillation activity is quite random.

Ionospheric irregularities have been associated with electron (or plasma) density fluctuations and structure. Some of these irregularities have been discussed by Ossakow[1] and Fejer and Kelly[2]. The irregularities act as a diffraction screen and superimpose random fluctuations of amplitude and phase on radio waves (from radio stars or artificial satellites) transmitted through them. The study of such random fluctuations of amplitude and phase (known as scintillation) gives information about the physical nature and the scattering mechanism of these irregularities.

There have been much statistical data concerning the morphology of these ionospheric scintillations which are found to occur in the nighttime F-region at equatorial latitudes[3-6]. Scintillation has been observed at frequencies ranging from 10 MHz to 6 GHz (Refs 7-9) and theoretical models have been presented to explain the physical processes involved[8,10-12].

Since the refractive index of the ionosphere is a function of radio frequency, irregularities in the ionosphere will have effect on the frequency of transmission. It appears that the frequency dependence is not constant but varies with ionospheric conditions. Many workers have estimated that it is inversely proportional to frequency, whereas others have estimated it to be inversely proportional to frequency squared and one has found it to be inversely proportional to the square root of frequency[13]. With the increasing use of satellites in communications and navigation, it is important to know how scintillation activity will affect such systems.

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Scintillation studies have been carried out in Legon, Ghana (lat., 5.63° N; long., 0.19° E) since 1965 when the first synchronous satellite visible from that part of the world was launched[13]. In this paper, a study of the variations of scintillation activity presented as depth of fade (D.F.) and scintillation index (S.I.) are presented for Marisat 1 (257 MHz, elevation 70°) for the period Jan-Dec. 1980. The correlation between scintillation and magnetic activity (K_p index) is also examined for the period.

Fig. 1 is a block diagram of the equipment used. A 30-foot parabolic antenna is used for receiving the signals. Details of the recording system have been described by Koster[13].

The receiver output was calibrated at regular intervals by putting in standard signal strengths measured in dB and observing the resulting recorder readings. By the least square method, these readings were fitted to a straight line which was used to convert recorder readings to signal strength. Signal strengths of up to 15-18 dB produced linear plots while there were severe deviations from a straight line for strengths greater than 20 dB[14].

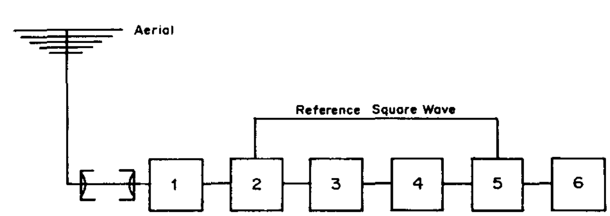

Fig. 1—Block diagram of the equipment used for scintillation study at Ghana (1, Phase splitter; 2, Phase switch; 3, Crystal controlled converter; 4, Communication radio receiver; 5, Phase sensitive detector with dc amplifier; and 6, Recorder)

The SI and DF are computed at 15-min intervals for each scintillation event through the relation

$$SI = \frac{P_{max} - P_{min}}{P_{max} + P_{min}} \times 100$$

and

$$DF = P_{max} - P_{min}$$

where P_{max} and P_{min} are the power in dB corresponding to the third highest peak and the third deepest trough, respectively, in the same 15-min interval.

The onset and cessation of scintillation are shown in Fig. 2. The average diurnal variation of depth of fade and scintillation index are shown in Figs 3 and 4 for each month, respectively, whilst Fig. 5 shows the monthly variations. The plot of correlation coefficient

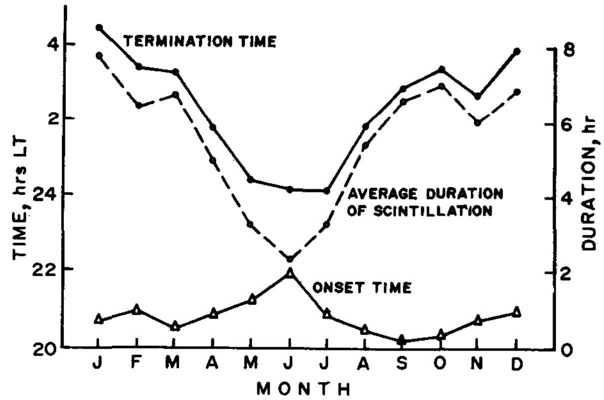

Fig. 2—Curves showing the onset and cessation of scintillation

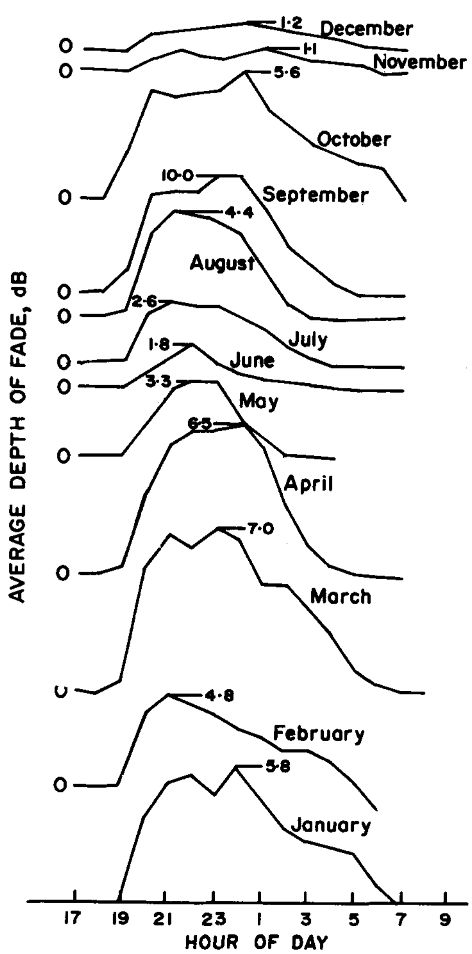

Fig. 3—Plots showing the variation of depth of fade for each month

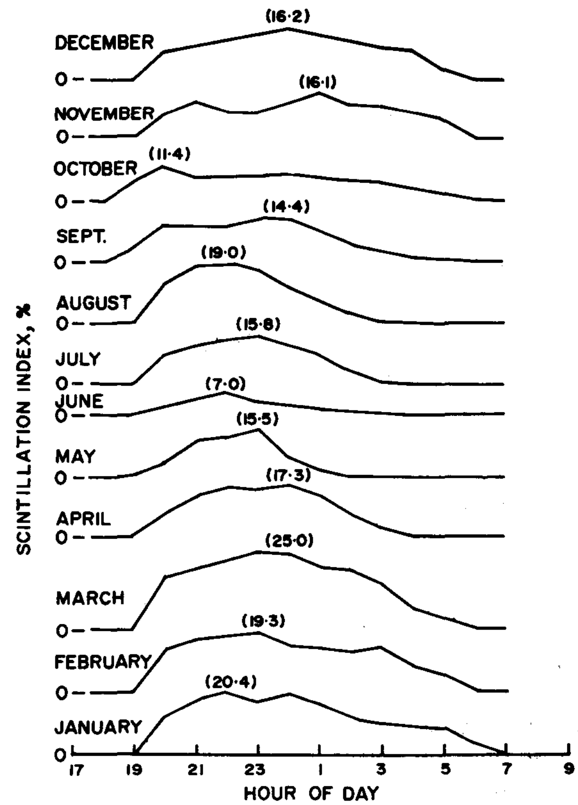

Fig. 4—Plots showing the diurnal variation of SI for each month (numbers in parentheses indicate the maximum SI)

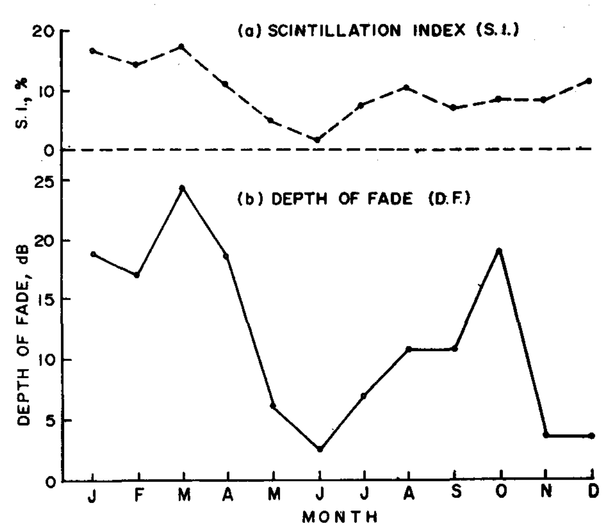

Fig. 5—Plots showing the average monthly variation of SI and DF

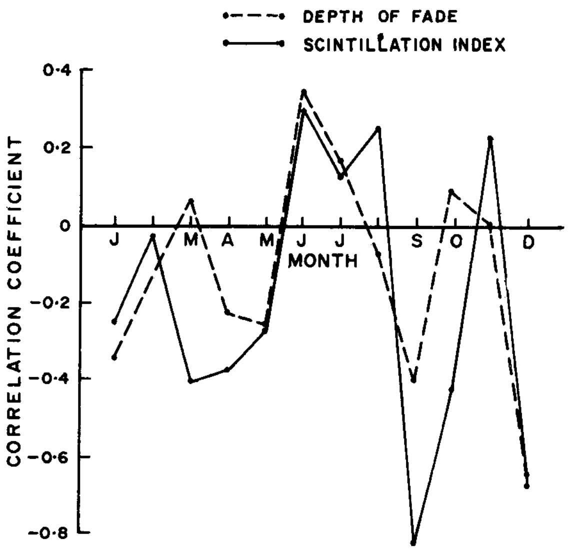

Fig. 6—Curves showing the correlation between magnetic activity (K_p sum index) and scintillation activity for each month

between the K_p sum (index) of magnetic activity for the day of the record and the integrated SI and DF for each day is shown in Fig. 6.

It is observed from Fig. 2 that scintillation activity lasts shortest in June. However, it is to be pointed out that for the period under consideration (Jan-Dec. 1980), only 18 out of the 30 days of June showed scintillation. The months January-March and September-November show the longest periods of scintillation activity. Scintillation usually starts at (20.5 ± 0.5) hrs and usually ends around (4.5 ± 0.5) hrs the following morning. The corresponding sunset and sunrise times (at height 350 km) are 19.2 and 4.8 hrs respectively.

Fig. 3 shows that the depth of fade rises to a peak (or sometimes two) before midnight and gradually decays to zero just before local sunrise. It also shows a maximum of 7 dB in March followed by a minimum of 1.8 dB in June, then a maximum of 5.6 dB in October and a minimum of 1.1 dB in November. Similar features are shown in Fig. 4 with scintillation index, being highest during the period January-April with a maximum of 25% (average) around midnight.

The above observations are confirmed from Fig. 5 which shows a peak each in March and October followed by a trough each in June and November/December. The variation of scintillation index, however, from September to January is relatively small, remaining around 16%.

The results shown are for the period Jan-Dec. 1980. This period is rather short for any meaningful deductions on scintillation activity. However, the general behaviour of scintillation during this period was found to be similar to previous reports from this station[13,15].

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