DIFFUSE TYPE AND BLANKETING TYPE SPORADIC E AT KODAIKANAL

H. CHANDRA AND R. G. RASTOGI

Physical Research Laboratory, Ahmedabad 380009 (India)

ABSTRACT

Ionograms at the equatorial station, Kodaikanal, are examined for a period of a solar cycle to study the occurrence of different types of sporadic E, *viz.*, the *q* type, the blanketing type, 'no-E_s' and night E_s. The daily, seasonal and solar cycle variations in the occurrence of different events at Kodaikanal are compared with the similar occurrence reported at African and American zones. Counter electrojet events greatly control the occurrence of different types of daytime E_s events.

INTRODUCTION

TOGETHER with the establishment of the rocket launching facility a number of ground based ionospheric experiments were set up at Thumba (dip 0·6° S), near magnetic equator in India to understand the physics of the equatorial ionosphere. The general features of the equatorial ionosphere based on the study of ionograms have been reported (Chandra and Rastogi, 1972 *a, b*). Due to rather small antenna and insufficient overall sensitivity of the ionosonde equipment in the initial stages the sporadic E at Thumba could not be critically examined. To highlight the features of equatorial E-region, ionograms at the neighbouring station, Kodaikanal (dip 3·4° N), were examined for a solar cycle period and the results compared with the ground magnetic and drift (closely spaced receiver method) data. The E-region in the equatorial ionograms is masked by intense sporadic E reflections during the daytime. Rangarajan (1954) has described that there are broadly two types of sporadic E at Kodaikanal.

(1) *Equatorial type.*—Denoted as E_{s-q}, is the most common type of sporadic E occurring very regularly during daytime and is characterised by its transparency to radio waves. The ground magnetic data shows presence of strong eastward electrojet at times of equatorial E_{s-q} and drift of electrons as measured by closely spaced receiver technique or backscatter technique is westward (Rastogi *et al.*, 1971; Rastogi, 1973).

We have pointed out a number of occasions when the E_{s-q} disappears and then the magnetic field value (H) drops below its mean night level and the drift of electrons is eastward, (Rastogi, 1972; Chandra and Rastogi, 1973). Such occasions are denoted by symbol 'G' in the publication of ionospheric data. Most of these counter-electrojet events occur in the afternoon hours and are more frequent during low sunspot years than during high sunspot years (Rastogi, 1974).

(2) *Blanketing* E_s known as $E_{s\,b}$.—This type of sporadic E usually occurs in the afternoon hours and is most common during J-months in the Indian zone (Bhargava and Subrahmanyan, 1964). The ground magnetic data show a very weak or reversed electrojet when this type of E_s occurs and the drift of electrons is predominantly from north to south direction. Equatorward convection of the E_s layers, from regions where wind shear mechanism can operate, due to Meridional wind is suggested as a possible mechanism to explain E_{s-b} in equatorial region (Chandra and Rastogi, 1974).

Night E_s is usually flat and low blanketing type in nature and no marked feature has been observed so far in the ground magnetic data at times of night E_s. The drift of electrons is in general eastward (Misra and Rastogi, 1971). In the present paper we report occurrence statistics of different types of E_s at Kodaikanal over a solar cycle period.

Occurrence of Daytime Sporadic E at Kodaikanal

The percentage occurrence of events during daytime hours, *i.e.*, E_{s-q}, E_{s-b} and 'no-E_s' plotted half hourly for the months June-July are shown in Fig. 1. The curves shown by dashed line represent high sunspot period and by full-line represent the low sunspot period. Figure 2 shows number of days E_{s-b} occurred each month and total number of half hourly E_{s-q} disappearance (07–17 hr) for each month. The salient features observed are :

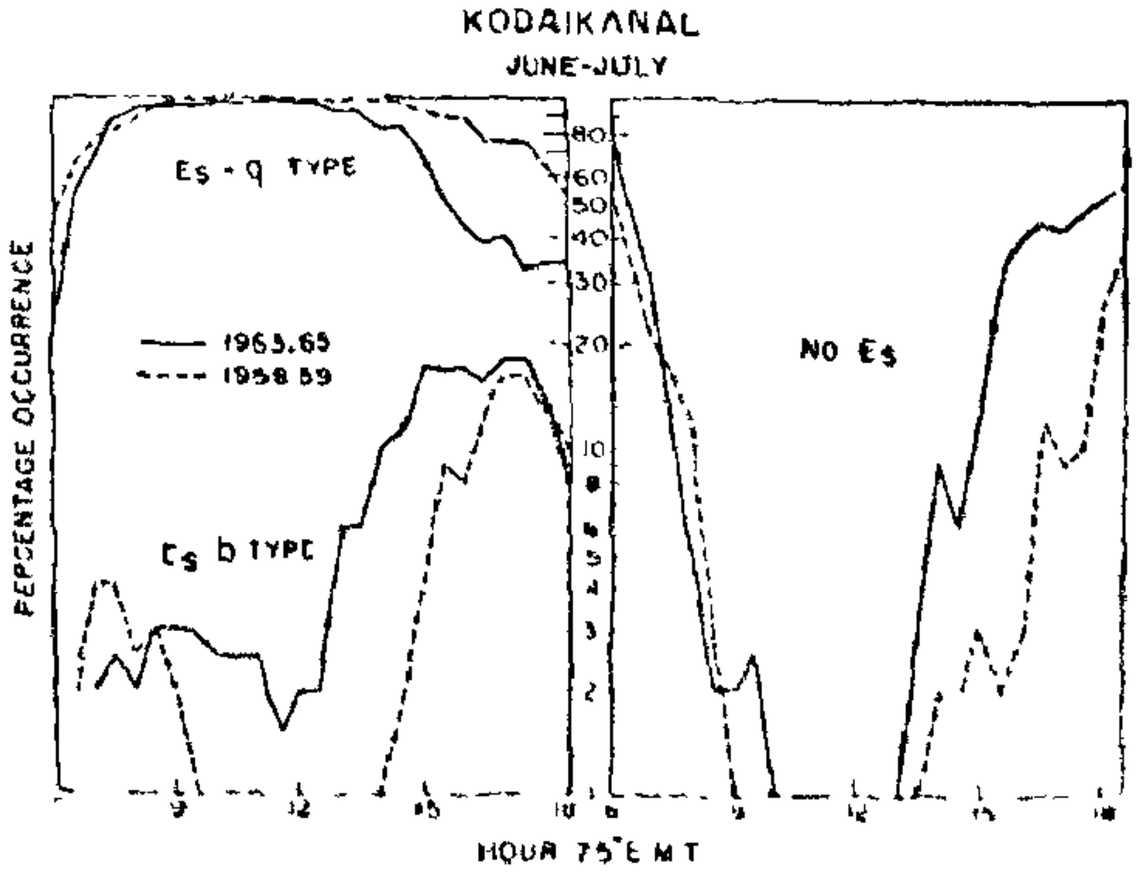

FIG. 1. Daily variations of the percentage occurrence of $E_{s\,q}$, $E_{s\,b}$ and 'no-E_s' during daytime at Kodaikanal for the months June-July of high and low sunspot years.

(*a*) occurrence of *q* type of E_s is more frequent during high sunspot years than during low sunspot years with maximum occurrence at midday when it is almost hundred per cent. The E_{s-q} occurrence in the afternoon hours is significantly less during low sunspot year (40% at 1600 hr).

(*b*) occurrence of blanketing E_s. It is more frequent during low sunspot years than during high sunspot years. It shows two peaks in the daily variation, one in morning (3%) and another in the evening (15–18%) with minimum at noon (less than 2% for low sunspots and nil for high sunspots). E_{s-b} occurrence is maximum during J-months (June–July).

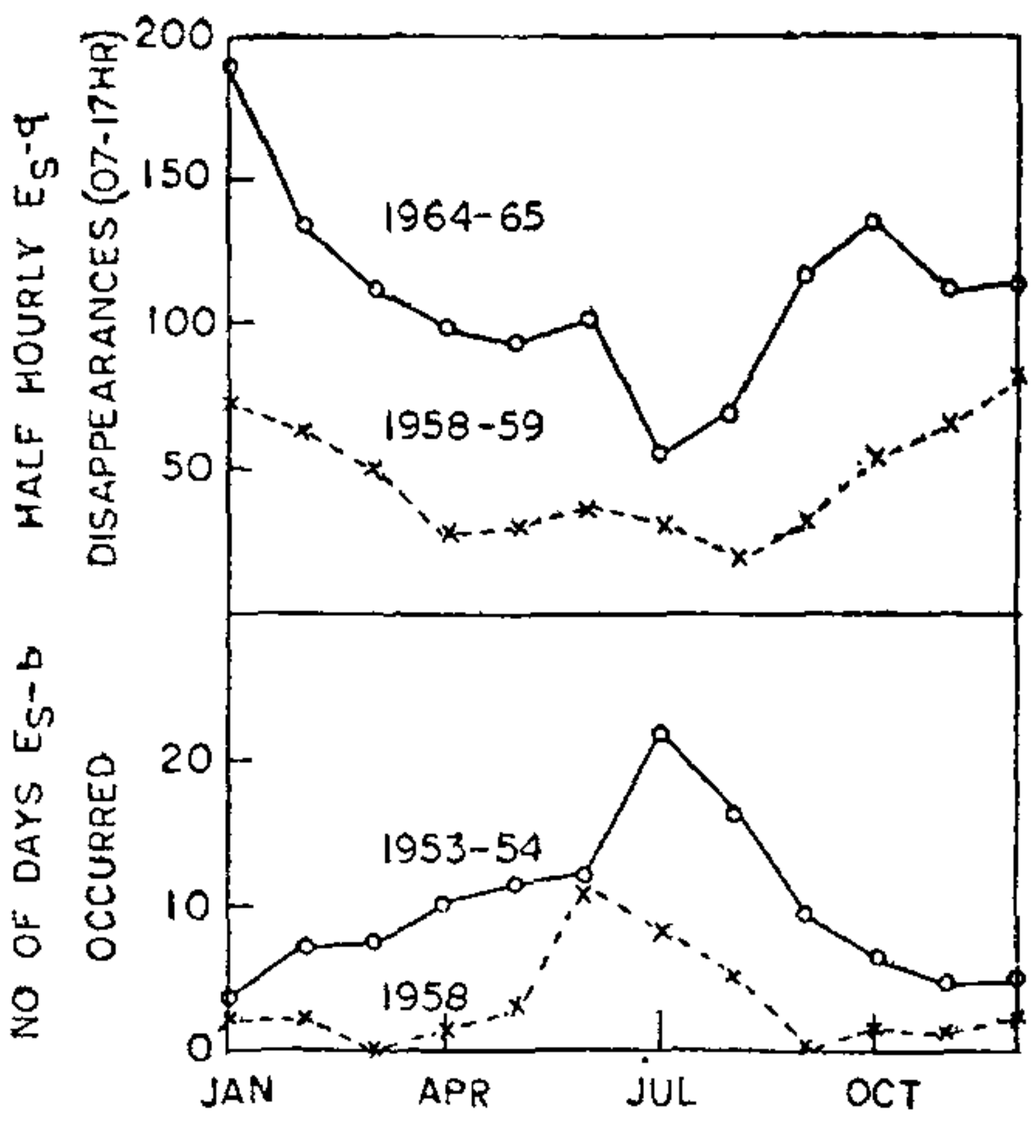

FIG. 2. Occurrence of $E_{s\,q}$ and $E_{s\,b}$ at Kodaikanal during different months of high and low sunspot years.

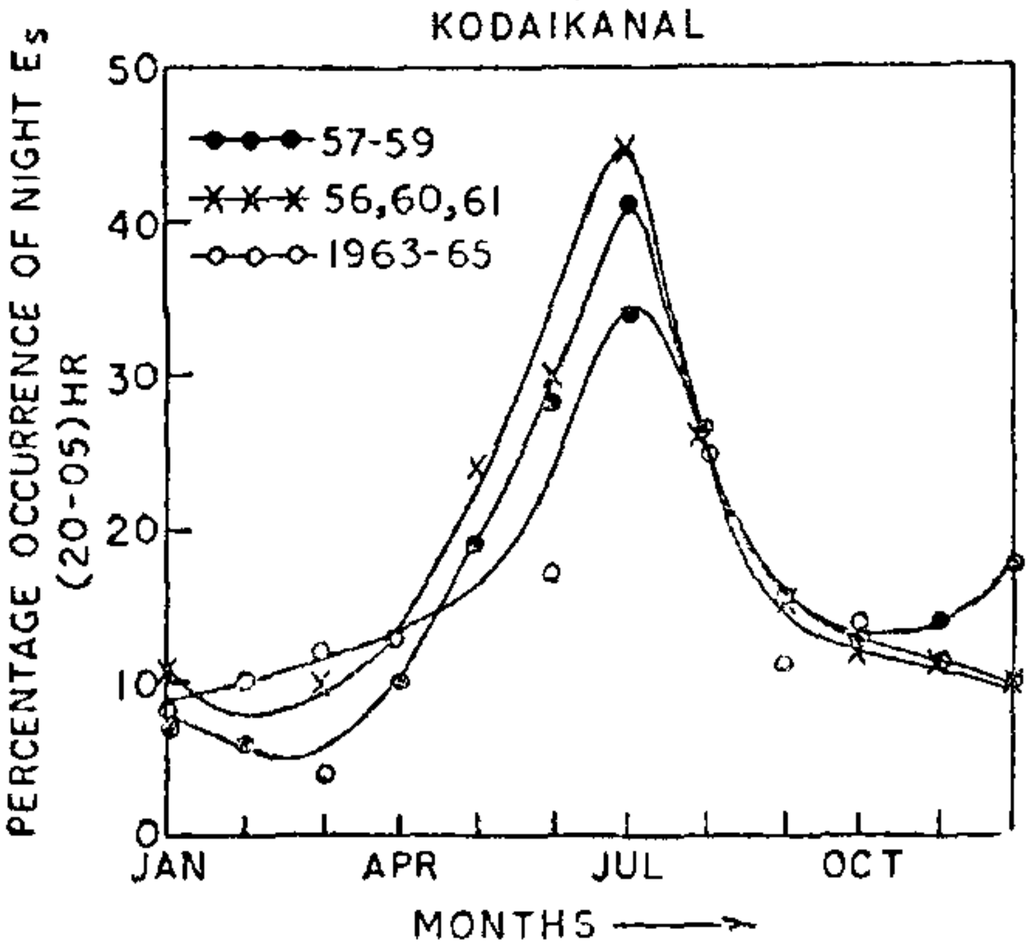

FIG. 3. Percentage occurrence of night E_s (20–05 hr) at Kodaikanal during different months of high, medium and low sunspot years.

(*c*) events when 'no-E_s' occurs are more frequent during low sunspot years than during high sunspot years. Its occurrence is nil at noon but quite significant in the afternoon hours (40% at 1600 hr of low sunspot years). Maximum cases of 'no-E_s' are observed during D-months.

Occurrence of Night E_s at Kodaikanal

Figure 3 describes the percentage occurrence of night E_s for different months during high, medium and low sunspot years. The nocturnal variations for each season during different periods of solar activity are shown in Fig. 4. The important results are :

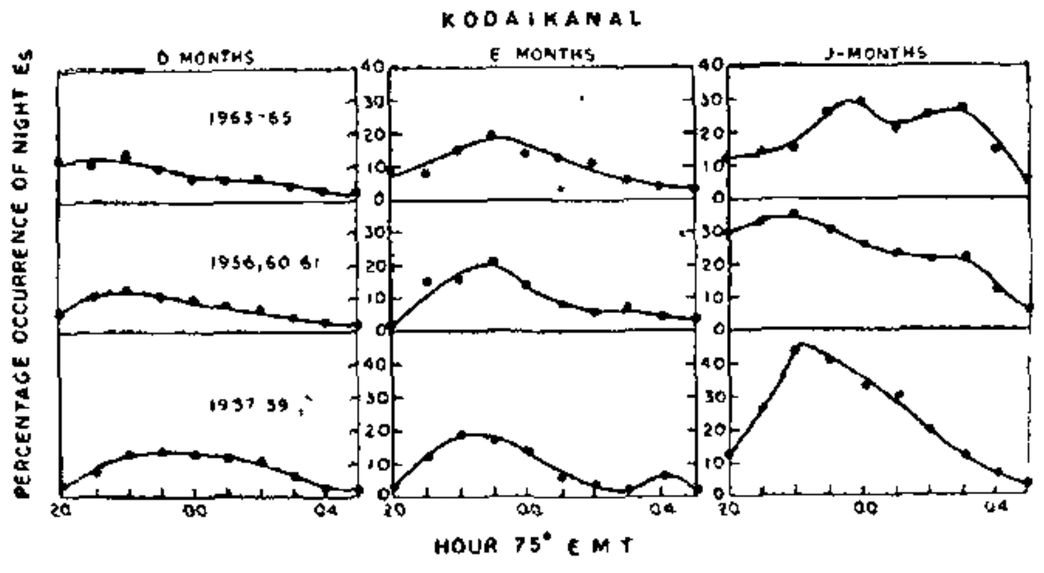

FIG. 4. Nocturnal variations of the percentage occurrence of night E_s at Kodaikanal during different seasons of the high, medium and low sunspot years.

(*i*) There is no significant effect of solar activity in the occurrence of night E_s. For each of the sunspot period, maximum occurrence is noted during J-months (July).

(*ii*) The peak occurrence of night E_s is obtained around 22–23 hr.

Comparison with the results at other equatorial stations.—A detailed study of the occurrence frequency of different types of E_s at Huancayo for the IGY was described by Bandyopadhyay and Montes (1963). The non-equatorial type, flat E_s layers, classified as E_{s-f} during nighttime and E_{s-l} (low type) during daytime were studied along with the *q* type. The events of 'no-E_s' during daytime were studied by them for IGY and year 1961–62. Oyinloye (1969) has described occurrence of *q* type and daytime blanketing type E_s at Ibadan for the period 1958–64 and for Zaria for the year 1965. From the results obtained at different equatorial stations one can summarize following points :

(*a*) E_{s-q}.—Occurrence increases with sunspot number with seasonal maximum in equinoxes (except at Ibadan). The daily variation shows a broad peak at noon, when occurrence is near hundred per cent at Huancayo, Zaria and Kodaikanal but significantly less at Ibadan. The 'no-E_s' events

known as disappearance of E_{s-q} are more frequent during low sunspot years than during high sunspot years. While at Kodaikanal its frequency is maximum in the afternoon hours, at Huancayo it is more common in morning hours during E-months and J-months and in afternoon hours during D-months.

(*b*) *Blanketing* E_s.—The results at Ibadan and Kodaikanal for blanketing type of E_s are similar which show minor morning peak and major evening peak (16–17 hr), maximum occurrence in J-months and increased occurrence with decreasing sunspot number. The percentage occurrence of evening peak at Kodaikanal (20%) is much higher than that obtained at Ibadan (5–10%). Oyinloye (1971) examined IGY data for the blanketing E_s ($foE_s - foE \geqslant 0{\cdot}5$–$1{\cdot}0$ MHz) and reported absence of morning peak both at Huancayo and Ibadan. He also reported maximum occurrence during J-months at both the stations; the occurrence being more at Ibadan (6·2%) than that at Huancayo (2·8%). The daily variations at the two stations showed a tendency for afternoon peak which was much clearer for Ibadan. Recently, Kelleher and Kasenally (1972) have reported that occurrence of blanketing E_s ($foE_s > 5{\cdot}0$ MHz) at the magnetic equator in the American zone being higher during D-months than during J-months, and an opposite trend at the equatorial stations in the African and far Asian zones. From the above results it seems blanketing E_s is most common in the Indian zone and least common in the American zone.

(*c*) *Night E*.—The E_{s-f} occurrence of Huancayo during the IGY was maximum in D-months with postmidnight peak (60%), and minimum during J-months (20%) with premidnight peak. At Kodaikanal the occurrence is maximum in J-months (45%) and minimum during D-months (10%), the peak occurrence is noticed around 22–23 in general for each season. Thus the occurrence of night E_s is more common in the American zone than in the Indian zone.

Discussions

The occurrence patterns of the different types of sporadic E during daytime at Kodaikanal are explainable in terms of the occurrence pattern of counter-electrojet currents. It has been shown that at times of normal electrojet E_{s-q} occurs, at times of counter-electrojet there is no E_s and at times of very weak (normal or reversed) electrojet with equatorward wind E_{s-b} occurs. Further the seasonal variation of the blanketing E_s outside the equatorial region shows maximum during J-months (in the Indian stations). In a similar fashion one can explain occurrence of similar events in the African and American zones.

Rastogi (1974) has shown that the counter-electrojet events occur mainly in the afternoon hours at Kodaikanal during all seasons. But at Huancayo the occurrence is comparable in the morning and afternoon hours during E- and J-months and mainly in the afternoon hours during D-months. The occurrence of counter-electrojet events at Kodaikanal is much more frequent than at Huancayo.

The occurrence of night E_s is independent of solar cycle and therefore needs entirely different explanation. Rocket measurements at Thumba during nighttime have shown existence of large-scale structure and presence of valley in the electron density profiles; the presence of irregularities was located mainly in the regions of negative density gradients (Prakash *et al.*, 1970). Presence of eastward electron drift at times of night E_s favours the nighttime irregularities at the altitudes of negative electron density gradients and caused by cross-field instability.

Beer and Moorcroff (1972) have suggested concept of a combined effect of ionization movements due to the wind shear mechanism and due to the cross-field gradient drifts and explained qualitatively the observed nighttime electron density profiles, and some of the features of the constant height type night E_s. This concept works efficiently for westward directed background electric field hence predominantly a nighttime phenomenon. Question remains then how to explain the seasonal dependence, *i.e.*, J-maximum in Indian zone and D-maximum in the American zone.

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