

BLANKETING SPORADIC E LAYER
NEAR THE MAGNETIC EQUATOR*

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ABSTRACT

A study of the ionograms obtained at Kodaikanal (dip lat. 1.7° N) during the period 1954–66 has shown that the daily variation of the occurrence of blanketing type of Es (Es-b) has a major peak around 1700 LT in the evening and a minor peak around 0800 LT in the morning, and is practically inhibited around midday hours when the electrojet currents are maximum. Further, Es-b is most frequent during local summer months and in the years of minimum solar activity.

In individual cases, Es-b occurs during the period of very weak or reversed electrojet currents. The ionospheric drifts during these occasions show predominantly a north to south component.

It is suggested that the equatorial Es-b is due to the transport and accumulation of long-lived metallic ions from tropical latitudes to the magnetic equator by equatorward winds, during the period when the electrojet currents are very weak and thus the upward Hall polarisation field is absent.

INTRODUCTION

The most common type of the sporadic E observed near magnetic equator is the equatorial type, Es-q, which is transparent to the radio waves and occurs very regularly during the daytime hours. Besides Es-q there are a few other types of sporadic E which occur in the equatorial region during daytime hours.

A detailed study of equatorial blanketing Es, denoted here as Es-b (classified as flat type, Es-f, by many authors), was first described for Kodaikanal by Bhargava and Subrahmanyam (1964). The diurnal variation of the occurrence frequency of Es-b showed a very pronounced peak (11%) between 1700 and 1830 LT, a minor peak (4%) between 0730 and 0830 LT and a minimum (1.5%) around 1130 LT. Seasonally Es-b was most predominant during summer (July) months.

In this paper we describe the association between Es-b observed in the ionograms at Kodaikanal (Geog. lat. 10.0° N, Geog. long. 77.5° E dip lat. 1.7° N) and the ionospheric drift measurements at Thumba (Geog. lat. 8.5° N, Geog. long. 77.0° E, dip lat. 0.6° S). Characteristics of Es-b as seen in the ionograms

Some of the ionograms of Kodaikanal showing abnormal Es are reproduced in Fig.1. The ionogram

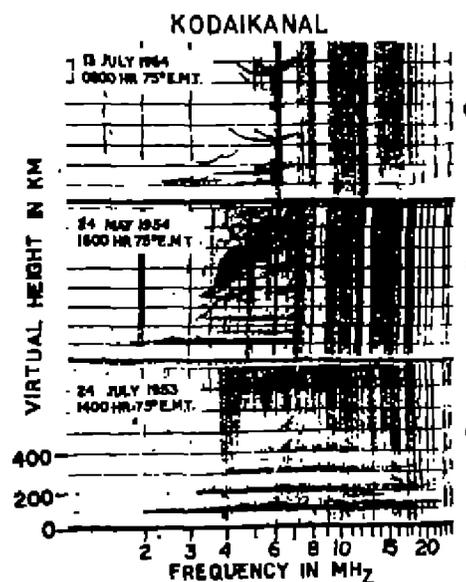


Fig. 1

in Fig.1(a) (24 July 1953, 1400 LT) shows the Es-b layer with a sharp lower boundary at 100 km; the maximum reflected frequency exceeds 22 MHz

and at least 4 multiple echoes can be identified. The upper F-region reflections, though not blanketed completely, are greatly weakened. These characteristics of Es are very different from those of Es-q. The record in Fig.1 (b) (24 May 1954, 1600 LT) shows the normal E layer trace upto about 2.5 MHz, diffused Es reflections at 105 km, as well as at greater ranges; a very sharp and continuous trace is seen emanating from E layer critical frequencies and extending to over 7 MHz. Its virtual height, except near the E region critical frequency, is practically constant at 120 km. In our study we have included this type also within Es-b. The ionogram in Fig.1(c) (13 July 1964, 0800 LT) shows reflections from normal E layer, from an Es-q layer, as well as from a higher sporadic layer at about 160 km. This is not included in our classifications of Es-b, as this does not blanket any part of F trace, nor does it make a multiple echo and therefore is probably oblique. **Seasonal, solar cycle and diurnal variations of Es-b occurrence**

The occurrence of Es-b in the half-hourly ionograms of Kodaikanal were noted for the daytime hours (0600-1800 LT) in the period 1954-66. It is found that the Es-b occurs mainly during the summer (June-July) months. Further, the number

of days with blanketing Es is found to be inversely correlated with solar activity. During the summer months of low sunspot year 1954, the Es-b was seen on about 18-20 days per month while during summer months of 1958, Es-b was seen only on about 10 days per month. The study of Es-occurrence at Ibadan by Oyinloye (1969) also indicated a higher frequency of occurrence during June (local summer) and inverse correlation with sunspot number.

The Es-b being more frequent during the local summer months, its occurrence frequency at different times of the day in summer (June-July) was computed for all the years. During each of the years the major peak of Es-b occurrence is in the evening hours between 1500-1700 LT; a minor peak is sometimes seen between 0700-0800 LT. Similar daily variation for Ibadan has been reported by Oyinloye (1969). **Association of Es-b with magnetic field changes**

Bhargava and Subrahmanyam (1964) have pointed out large changes in the geomagnetic field during the periods of occurrence of Es-b at Kodaikanal. Our study of the disappearance of Es-q associated with the depression in the H component of the magnetic field had indicated that during the recovery phase of a temporary depression of geomagnetic field, blanketing type of Es sometimes develops,

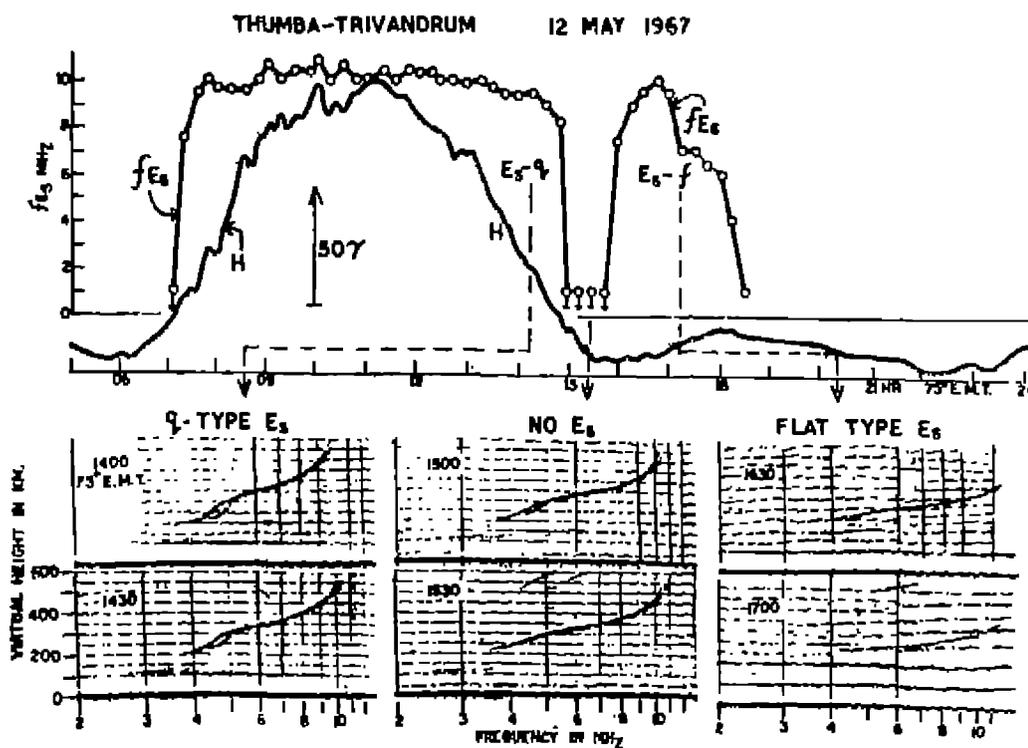


Fig. 2

though the geomagnetic field was below its night level. An example of the changes in Es during the depression in the geomagnetic field at the equatorial station Thumba (Trivandrum) is shown in Fig.2. On a quiet day, the geomagnetic field at Thumba starts increasing after sunrise, reaches its maximum an hour before midday and returns to the nighttime level by the evening hours. On 12 May 1967, a significant minimum of the H field was noticed at 1800 LT. During the period when the electrojet was well developed, the fEs values were high and the Es was of the equatorial q type. After 1445 LT when the H field went below its night level, the Es layers suddenly disappeared and for a period of one hour between 1500 LT and 1600 LT, clear normal E layer reflections were recorded in the ionograms. During the later part of the depression in H, strong Es reflections were again noticed. The character of this blanketing (flat in the figure) type of Es is very different from those of the q type Es recorded before 1430 LT. The blanketing type of Es showed as many as four multiple reflections and blanketed part of the F traces. Similar associations between Es-q disappearance and Es-b occurrence at Thumba and Kodaikanal were noticed on a number of occasions. The simultaneous examinations of magnetograms and the ionograms at Kodaikanal further showed that during the period of Es-b occurrence, the electrojet as indicated by H values was very weak or even reversed in direction.

The ionospheric drift measurement during Es-b occurrence

Besides the study of blanketing Es from the ionograms, such cases were monitored while recording the fading of ionospheric echoes with a spaced antennas drift experiment conducted at Thumba. The observations were taken on two frequencies; 2.2 MHz for the E-region and 4.7 MHz for the F-region. On occasions when strong reflections were observed from the E-region both on 2.2 MHz and 4.7 MHz, and F-region reflections were blanketed, the existence of blanketing Es was interpreted. Fig. 3 shows the mass plot of the apparent drift vectors computed from the simple similar fade analysis during periods of no-Es condition and during the presence of blanketing type of Es. As reported earlier (Rastogi et al., 1971) the drift is predominantly eastward

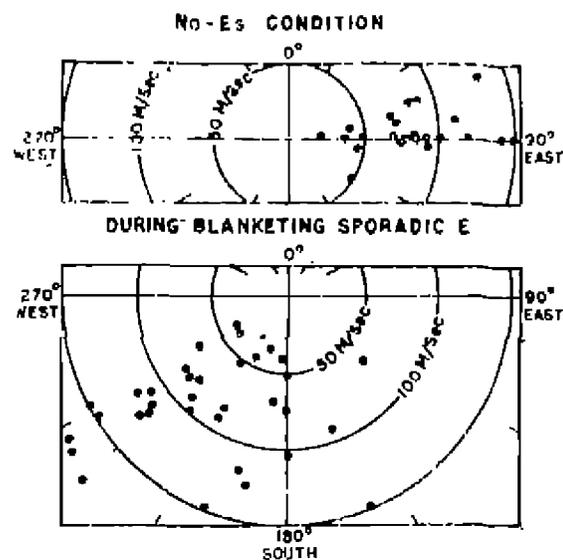


Fig. 3

during the absence of Es-q. But during the presence of Es-b large N-S component of drift is seen in all cases, the direction being southward. This is in contrast to the drift measurements at Thumba which show an entirely westward drift during daytime and entirely eastward drift during nighttime with no N-S component seen even at the time of reversals (Chandra and Rastogi, 1970; Misra and Rastogi, 1971).

The ionosonde at Thumba started operating in October 1964. The ionograms at Kodaikanal were therefore used for studying blanketing Es events in relation to the drift measurements at Thumba. About 20 occasions were found during the year 1964 when blanketing type of Es occurred at Kodaikanal and drift measurements were available at Thumba. A sharp rise in f_oE_s was noticed whenever blanketing Es occurred and this was accompanied by simultaneous increase in the f_bE_s values. The f_bE_s values of blanketing Es often exceed 20 MHz in comparison to the f_oE_s values of q type Es which generally range from 8 to 12 MHz. On most of the occasions of strong blanketing Es, the F-region trace is completely blanketed and f_oF_2 is not measurable. Such occasions are denoted by the symbol 'A' in the ionogram scaling.

Fig. 4 shows one such event on 12 July 1964 when strong blanketing Es occurred at 1530 LT. Simultaneous increase of f_oE_s and f_bE_s is noticed and even f_oF_2 is not measurable as the whole F

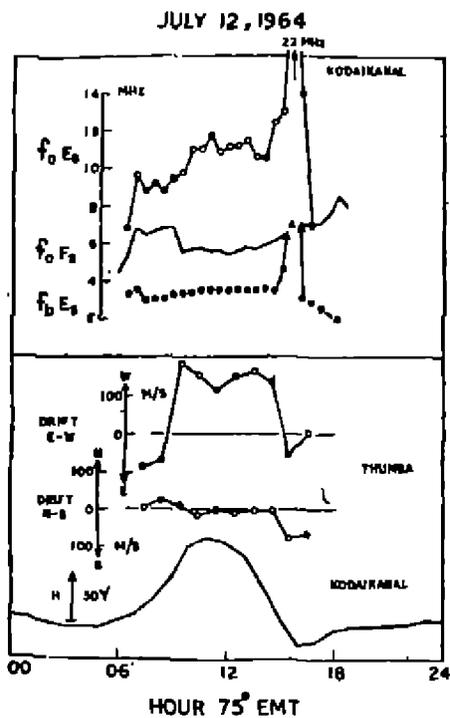


Fig. 4

layer is blanketed. The H variation on this day showed a depression at about the same time. The drift was westward till 1430 LT and reversed to eastward at 1530 LT. The N-S component was absent or insigni-

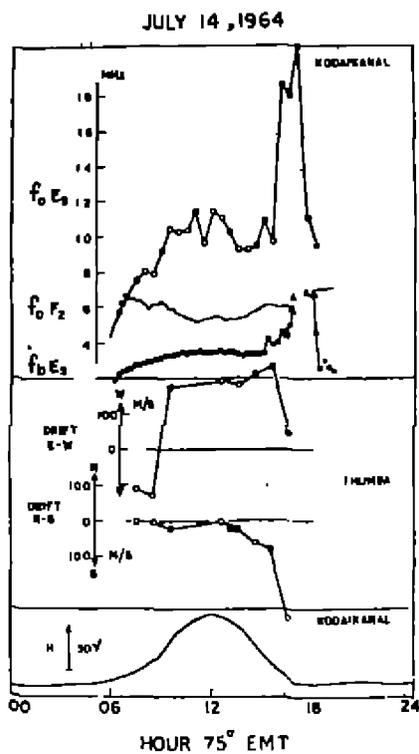


Fig. 5

ficant till 1430 LT but at 1530 LT and 1630 LT

large southward drift was present. Fig. 5 shows another event on 14 July 1964 when blanketing Es was seen from 1600 LT to 1800 LT. Large southward drift was present at 1530 LT and 1630 LT. The E-W component though westward, dropped to a very low value at 1630 LT.

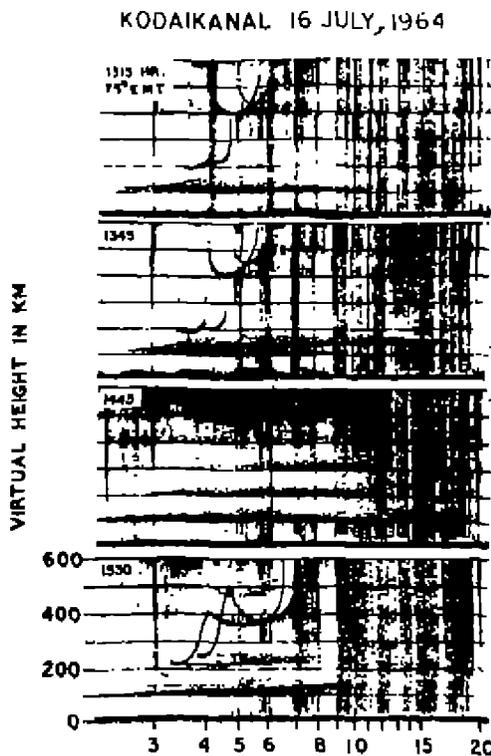


Fig. 6

An example showing the development of a strong blanketing Es at Kodaikanal is shown in Fig. 6. The event occurred on 16 July 1964. Es-q was present till 1315 LT. At 1345 LT, one can notice both Es-q (100 km) and another Es trace at 130 km. At 1445 LT the F-region trace is completely absorbed and multiple Es echoes are observed. The blanketing layer dies slowly and at 1530 LT one again finds transparency of the Es layer. The spaced antenna fading records on this day were analysed by a full-correlation method. The daily variations of the magnetic field (H), E-W and N-S components of true drift (V_{E-W} and V_{N-S}), drift direction (ϕ), and parameters f_0F_2 , f_0E_3 and f_1E_3 on this day are shown in Fig. 7.

The H variation on this day indicated a depression in H around 1500 LT. The E-W drift component was towards west (100 m/sec) before the depression but reversed to eastward (20 m/sec) at 1630 LT. The N-S component of drift which was completely

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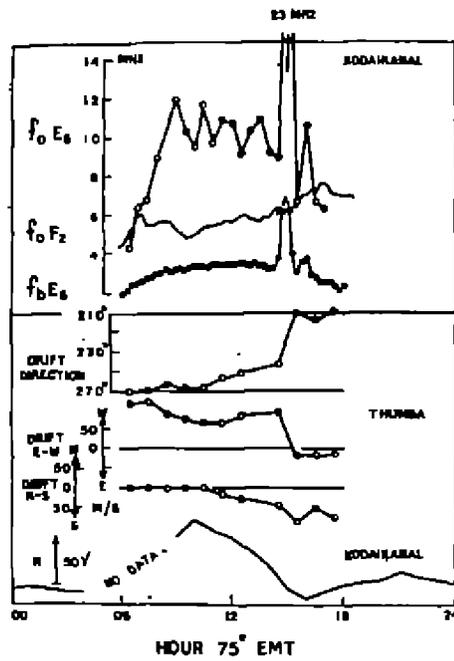


Fig. 7

absent until about noon became southward later and from 1430 LT to 1730 LT it was of the order of 50–100 m/sec. The most significant change is seen in the drift direction, which is towards west before noon and changes towards southwest afterwards. At the time of Es-b the drift direction was entirely southward.

During these Es-b occurrences, the blanketing echoes are first seen at virtual heights of 150 to 200 km and it decreases with time till upto 100 km when the number of multiple reflections are also maximum. Assuming that these patches of intense ionisation move horizontally towards the station, the horizontal distance of the cloud can be calculated and therefrom the horizontal velocity of the clouds. The variation with the time of the slant range and horizontal distance of the cloud on 16 July 1964 is shown in Fig.8. From the slope of the distance versus time curve, the horizontal speed is computed to be about 37 m/sec. This value corresponds closely to the N-S component of the drift derived from spaced receiver experiment. This gives further clue that the Es-b in Indian zone is consequent to the southward movement of Es clouds.

Thus the occurrence of the blanketing Es at the equator in the Indian zone is associated with the depression in the horizontal component of the geo-

magnetic field and with the occurrence of the southward ionospheric drifts.

DISCUSSIONS

The blanketing type of Es commonly observed at temperate latitudes is explained in terms of the convergence of metallic ions due to the vertical wind shears but this mechanism fails to operate at the dip equator (Axford, 1961; Whitehead, 1961; Axford and Cunnold, 1966; Whitehead, 1966). Cross (1971) has shown that suitable electric fields can produce a convergent flow of metallic ions and cause blanketing Es at dip 2-3 degrees. However, our results show that electric fields are nearly absent whenever blanketing type of Es is formed.

N-S MOVEMENT OF BLANKETING E_s LAYER

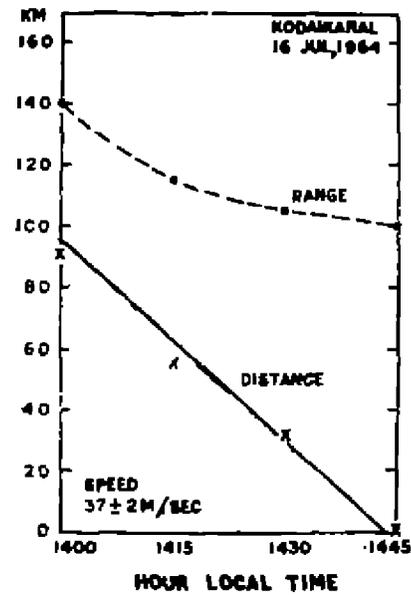


Fig. 8

Blanketing type of Es has been observed at Thumbaa by Reddy and Devasia (1973) and they propose short period gravity waves induced horizontal shears of horizontal neutral winds around 100 km level responsible for the formation of such layers. The occurrence patterns of the blanketing Es however cannot be explained by this theory.

The convection of Es layers then remains possible mechanism. Thus a movement of ionization layers from higher to lower latitudes or even to magnetic equator due to a horizontal wind with significant north-south component, could explain the occurrence of Es-b near magnetic equator.

North-south drift of 50–100 m/sec can transport such layers from a dip latitude greater than 3° where it can be formed by wind shear mechanism, to dip equator in less than its life time. It is to be noted that blanketing Es at Kodaikanal occurs mostly during June-July months when Es layer is very strong at northern temperate latitudes. Thus according to this mechanism Es-b at equator should occur at times when the meridional wind is strong.

The observed features of the occurrence of Es-b could be explained on the basis of the occurrence of counter-electrojet events. Rastogi (1974) has shown that these events at Kodaikanal occur mostly in the afternoon hours with small occurrence in the morning and are almost absent around noon hours. Further, the counter-electrojet events are maximum during low sunspot years and minimum during high sunspot years. Thus the observed daily and solar cycle variations are very similar for the occurrence of blanketing Es and the counter-electrojet. As for the seasonal variation, one has to note that Es at temperate latitudes is local summer phenomenon and we find presence of eqator wind only during summer months when blanketing Es events are observed. Whether such layers do move towards Equator can be tested by having a close chain of ionosondes near the manetic equator.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. M.K.V. Bappu and Dr. J.C. Bhattacharyya of the Indian Institute of Astrophysics, Kodaikanal for providing all the facilities to study the ionograms and the megnetograms at their observatory. Thanks are also due to professor K.R. Ramanathan, Dr. P.K. Kaw and Dr. T.E. Van Zandt for helpful discussions.

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FIGURE CAPTIONS

- Fig.1 Sample ionograms showing non q type Es layers observed at Kodaikanal.
- Fig.2 Temporal variations of fE_s and geomagnetic H component at Thumba/Trivandrum on 12 May 1967. Ionograms shown below indicate the q type Es, its disappearance following a depression in H and later the development of multiple types Es during the later part of the depression.
- Fig.3 Mass plot of the apparent drift vectors at Thumba during the occurrence of blanketing Es.
- Fig.4 Variations of f_oE_s , f_bE_s , and f_oF_2 at Kodaikanal on 12 July 1964. Also shown are the N-S and E-W components of apparent drift speed at Thumba and the geomagnetic H component at Kodaikanal on the same day. Note the blanketing of the F_2 layers, denoted by 'A' at 1630 LT.
- Fig.5 Variations of f_oE_s , f_bE_s , and f_oF_2 at Kodaikanal on 14 July 1964. Also shown are the N-S and E-W components of apparent drift speed at Thumba and the geomagnetic H component at Kodaikanal on the same day.
- Fig.6 Ionograms for Kodaikanal showing disappearance of Es-q layer, and development of strong blanketing type of Es with total absorption of F layer on 16 July 1964.
- Fig.7 Variations of f_oE_s , f_bE_s , and f_oF_2 at Kodaikanal on 16 July 1964. Also shown are the N-S and E-W components of true drift speed at Thumba and the geomagnetic H component at Kodaikanal on the same day.
- Fig.8 Temporal variation of the apparent minimum range of the Es echoes and the computed horizontal distance of the Es cloud.