UNUSUAL RADAR METEOR COUNTS
IN 1963 AND THE SPORADIC—E
CHAPTER VII

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UNUSUAL RADAR METEOR COUNTS IN 1963 AND THE SPORADIC-E IONIZATION

1. INTRODUCTION

McINTOSH and MILLMAN (1964) reported a 50 per cent increase in the rate of radar meteor counts (all echoes) during the middle months of the year 1963 over the average rate for the five years 1958-62 and also a significant increase over the counts in the year 1962 (Fig.7.1) on a radar frequency of 32.7 MHz near Ottawa (45.2°N, 75.5°W).

A similar but larger, about 100 per cent, increase in the meteor rate was reported by ELLYETT and KEAY (1964) during the year 1963 over that in 1960 on a higher radar frequency of 69.5 MHz at Christchurch (43.5°S, 172.8°E). As seen in Fig.7.1, the normal hourly rate of all meteor counts at Ottawa is about 200 and at Christchurch (Fig.7.2) it is about 70.

The ionization occurring irregularly in the E-region of the ionosphere, namely the sporadic-E layer ionization has probably some relation with the meteors. It is since long known that bursts of ionization and radio echoes at a height of 95-105 km on different frequencies observed at high and midlatitudes were attributed to the shower and sporadic meteors
Fig. 7.1 Monthly mean radar meteor echo rates observed at Ottawa. Heavy continuous line is the five-year 1958-1962 average. Light separated lines are for 1962 data only and dotted lines are for 1963 data (after McIntosh and Millman, 1964).

By a number of workers (SCHAFFER & GOODALL, 1932; SKELLET, 1935; MITRA et al., 1935; APPLETON et al., 1937; APPLETON & PIDDINGTON, 1938; HEY et al., 1947; LOVELL et al., 1947; DIEMINGER, 1952; NEUZIL, 1955). APPLETON and NAISMITH (1947) showed that the nighttime diurnal variation and seasonal variation of occurrence of Es echoes on 27 MHz had similarities with the variations of the incidence of sporadic meteors. NAISMITH (1954) went a little further and called the Es at 95-105 km as 'Meteoric
Fig. 7.2 Mean hourly rate of meteor echoes observed by radar from Christchurch (after Ellyett and Keay, 1964).

LOVELL (1957) also believes that some forms of sporadic-E are caused by meteors. SWENSON (1969) reported that communication in Australia via the nighttime Es layer over Cape York on 1 to 2 MHz was possible for 70 to 90% of the total time, and for 30 to 50% of the total time over Port Moresby. WHITEHEAD (1966) found that his attempts to correlate the Es-ionization with the 2-8 °A X-radiation from sources outside the solar system discovered by GIACCONI et al (1962) were not successful. FIOCCO (1966) has, however, pointed out that the energy input of extraterrestrial dust may be
sufficient to maintain electron densities of the order of $10^5 \text{ cm}^{-3}$ in a thickness of 10 km with effective recombination coefficient $10^{-8} \text{ cm}^3 \text{ sec}^{-1}$. Even with low ionization efficiency, this dust may be sufficient for the nighttime background Es ionization.

In low latitudes, however, there are some conflicting reports. To quote a few, McNicol and Gipps (1951) and Thomas (1956) at Brisbane (27.5°S, 153°E) and Rangarajan (1954) at Kodaikanal (10.2°N, 77.6°E) did not find any changes in Es intensity or its occurrences which can be attributed to the meteors. But Kotadia (1958) gave several instances showing positive effects of meteor showers on the Es- ionization at Ahmedabad (23°N, 72.6°E) and Yamagawa (30.2°N, 130.6°E); one such instance is reproduced in Fig. 7.3.

In a recent paper, Kotadia (1969) has shown that the seasonal variation of the occurrences of the low type of Es(Esl) at Ahmedabad is not symmetrical around the summer, but it shows quite large occurrences in the second half of the year. This agrees with the fact that most of the meteor showers occur in the later half of the year.

The present study was undertaken in search of an abnormality, if any, in Es at European midlatitude stations during the period of large increase in radar meteor counts in 1963 reported by McIntosh and Millman and Ellyett and Key. 
Figt 7.3 The top frequency (fEs) of reflection by Sporadic-E layer and rate of meteoric incidence during the Quadrantids shower (after Kotadia, 1958).

Es-data of Freiburg (48°N, 7.6°E), Lindau (51.6°N, 10.1°E) and Sottens (46.8°N, 7.8°E) were examined. These places fall in the same latitude zone as of Ottawa and Christchurch where radar meteor counts were recorded.

2. RESULTS

The occurrences of Es with fEs > 3 MHz, the lowest
limiting frequency, expressed as percentages of total number of successful observations at Freiburg are shown in Fig. 7.4 for each month of the three years 1962-64. No distinction is made between different types of Es in the total occurrences. It is seen that there is no significant difference in the occurrences of Es during the year 1963 from those in 1962 and 1964.

![Graph showing monthly mean occurrences of sporadic-E layer at Freiburg with $f_{Es} > 3$ MHz during the years 1962-64.](image)

**Fig. 7.4** Monthly mean occurrences of sporadic-E layer at Freiburg with $f_{Es} > 3$ MHz during the years 1962-64. (All types of Es taken together).

Actually, very large increase in the rate of meteor counts was recorded in the months of June, July and August 1963, but no such increase was observed in the occurrences of Es with $f_{Es}$ greater than 3 or 5 MHz. Almost the same type of
variation in Es- occurrences was found at Lindau and Sottens, the percentages at Lindau being generally higher than at Freiburg for all the years under study.

Now meteoric Es ionization is known to occur in the height range 95-105 km (NAISMITH, 1954; KOTADIA, 1958), so the occurrences of the low type of Es were further examined. Fig. 7.5 gives the variation of such occurrences of the low type of Es(Esl) for all frequencies at vertical reflection.

![Figure 7.5 Monthly mean occurrences of the low-type of Es at Freiburg for all fEsl during the years 1962-1964.](image-url)
It is clear that Esl was less frequent in 1963 than in 1962 or 1964. In fact, its occurrences were most frequent in 1964, a year of low sunspot activity.

For the first four months when the meteoric rate was normal, the occurrences of Esl increased steadily from 1962 to 1964 i.e. as the sunspot activity decreased. From May to September 1963, however, a decrease was found in the occurrences of Esl corresponding to a large increase in the radar meteor counts.

McINTOSH and MILLMAN (1964) had further shown (Fig. 7.1) that the hourly rate of meteor radar reflections of duration greater than or equal to 8 seconds did not show any increase in 1963 over that in 1962 or the five-year average. This would mean that the sizes (of the increased number?) of meteorites entering the E-region were too small to give any long enduring radar reflections. Against the large increase (90 per hour) in radar meteor counts during May to September 1963 at Ottawa and Christchurch i.e. about 50 % and 100 % increase respectively at the two places, we find a reduction in the occurrences of Esl at Freiburg. The normal percentage occurrence of Esl in that period was about 15-17 %, while it decreased to 5-7 %, i.e. a reduction of about 66 % of the normal against the increase in radar meteoric count rate of about the same order.
3. DISCUSSION

The result that the unusual increase in radar meteor counts during the year 1963 was not accompanied by a similar increase in the occurrences of the Es at 95-105 km, but instead a fall in its occurrences was found leads to some doubt whether the increased radar counting rate of meteors was really an indication of a worldwide increase in the influx of extra-terrestrial dust particles or meteorites. The re-entry of orbiting dipoles (needles) appears to be ruled out by the data already published (1962).

A clue to the above finding of unusual increase of radar meteor counts and decrease in the occurrences of the low type of Es during the same period is then to be sought in some other common cause. There are some encouraging reports from which we can perhaps get a solution of the problem of explaining the above observed phenomena.

LINDBLAD (1967) reported that the mean air density in the meteor zone (95-105 km) varied by a factor of 1.7 over a solar cycle as seen from two peaks in the radar visual heights of Perseid meteors near the sunspot minimum years 1953 and 1963. Further, air density at this height measured by a falling sphere dropped from rocket and by satellite drag methods was found high in 1963, about 1.5 to 2 times that in 1962. STEIGER (1966) found that there was a considerable
increase in the intensity of sodium-line radiation in the night airglow over Hawaii during the year 1963, meaning probably an increase in sodium vapour in the height-region of the night airglow, presumably the E-region. MILLMAN (1969) feels that the increase in the radar meteor counts observed in 1963 was connected with atmospheric changes rather than a real increased influx of meteors and he is inclined to agree in main with Lindblad's comments that increase in the air density would shift the radar detection threshold so as to give increased counting rate, although the situation is far more complicated than a simple dependence on the basic solar cycle.

From the findings of Lindblad and Steiger and the comments of Millman, it may be stated that the increase of 50% to 100% in radar meteor counts might have been due to an increase in the air density of about the same order at the 95-105 km heights region of the ionosphere. Such increase in the air density could also result in a 'Sink' for the Es ionization by the process of attachment of electrons to the neutral particles and could account for a decrease of about 60-70% in the occurrences of Es. Thus the common cause for the increase in the radar meteor counting rate and decrease in the occurrences of Es might probably be the increase in the air density at 95-105 km height and not the increase in the influx of meteors.
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