On some characteristics of the field intensity of atmospherics at Calcutta due to local active monsoon clouds

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सार — स्थानीय सक्रिय मानसून के बादलों से संबंधित, हार्मोनिक प्रकार से संबंधित तीन आवृत्तियों पर, वायुमंडलीय प्रक्रिया की क्षेत्रीय तीव्रता के स्तर के कुछ अभिलक्षणों का परीक्षण प्रस्तुत किया गया है। वायुमंडलीय प्रक्रिया और स्थानीय वर्षा के मध्य, अपरान्ह न्यूनतम के साथ प्रात: न्यूनतम और अपरान्ह अधिकतम के साथ प्रात: न्यूनतम के अनुपात के मौसमी परिवर्तनों का समालोचक विश्लेषण किया गया है। इन दोनों अनुपातों के अंतर निश्चित मौसमी परिवर्तन के साथ मानसून महीनों के दौरान न्यूनतम मान भी प्रदर्शित करते है। ऐसे अवसरों पर वर्षा की मात्रा में वृद्धि के साथ सार्थक अनुपात कम हो जाता है जो कि स्थानीय प्रक्रियाओं से संबंधित होता है। परिणामों से यह भी पता चलता है कि ऊपर छाए हुए बादलों की मात्रा (ऑक्टा), विभिन्न आवृत्तियों की तीव्रता के स्तर और वायुमंडलीय प्रक्रिया के विस्तार में किस प्रकार उल्लेखनीय रूप में सहायक होती है।

ABSTRACT. The paper examines some characteristics of the field intensity level of atmospherics at three harmonically related frequencies due to local active monsoon clouds. Seasonal variations of the ratio of afternoon maximum to morning minimum as well as that of the afternoon minimum to morning minimum of atmospherics and the local rainfall have been critically analysed. The differences of the two ratios exhibit a pronounced seasonal variation, having minimum values during the monsoon months and also the significance ratio at such times decreases with the increase of rainfall, which, in turn, is related to local sferics. The results further indicate how the overhead cloud amount in okta contributes significantly over the intensity level of different frequencies and width of atmospherics.

Key words — Atmospherics, Maximum. Minimum, Intensity, Frequency, Cloud amount, Monsoon cloud, Rainfall.
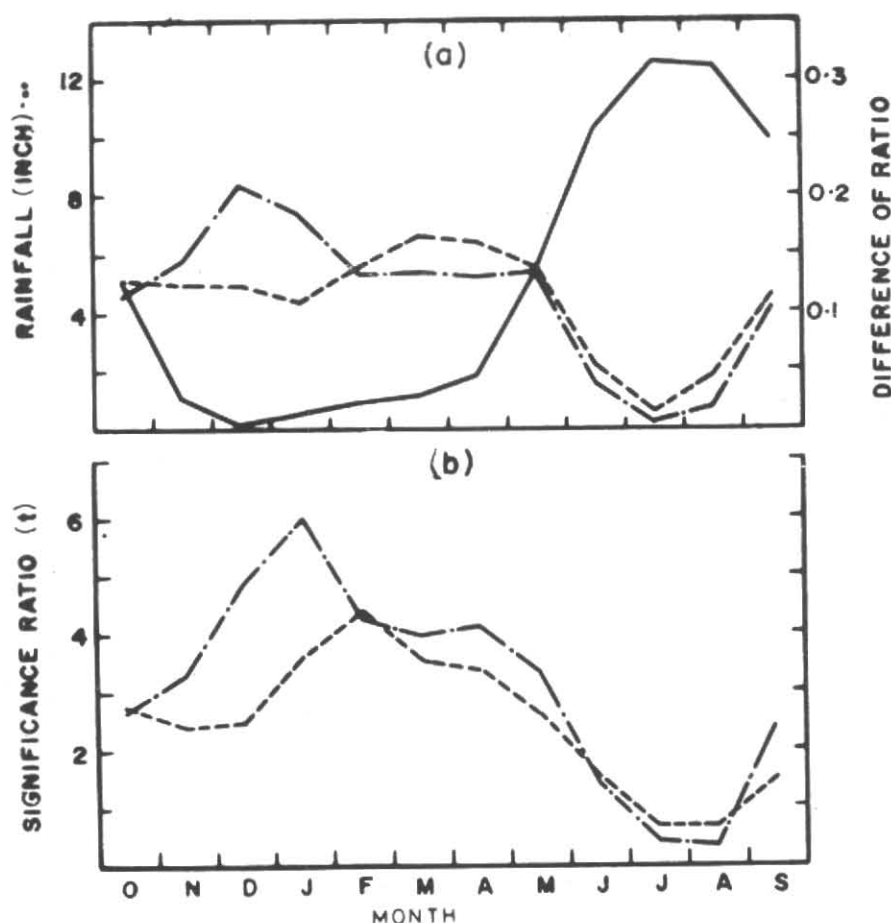
1. Introduction

The study of monsoon activity in the tropical region has always been a subject of great interest. A period of heavy rainfall during monsoon season is usually known as active monsoon and that of light rainfall as weak monsoon (Paul and Sikka 1976). In India, during the southwest monsoon season (June to September), the rainfall over large parts of the country fluctuates between heavy to light amount. The present observations have been taken over Calcutta (Lat. 22°34'N, Long. 88°24'E) whose geographical location is only about 150 km away from the Bay of Bengal where monsoon clouds are initially developed. During the monsoon months the atmospheric sources originating in local clouds have dominant role over other widely distributed weak sources as observed on radar screens. It is the

purpose of the present paper to examine the effect of monsoon clouds on the field intensity level of atmospherics.

2. Significance level of atmospherics

An attempt has been made in this section to examine the variations of Integrated Field Intensity of Atmospherics (IFIA) between morning and afternoon hours over Calcutta in relation to the activity of the sources. Round-the-clock records of IFIA at 10, 20 and 30 kHz over Calcutta have been analysed. A typical record of IFIA at the above three frequencies has been published previously (Bhattacharya *et al.* 1980) which exhibits all the well known regular variations (WMO 1957). The changes of noise level from the morning minimum to the afternoon maximum or to the late afternoon minimum

Figs. 1 (a & b). (a) Monthly variation of

$$\left(\frac{A_{max}}{M_{min}}\right)_{10\ kHz} \sim \left(\frac{A_{max}}{M_{min}}\right)_{30\ kHz} \text{ and } \left(\frac{A_{min}}{M_{min}}\right)_{10\ kHz} \sim \left(\frac{A_{min}}{M_{min}}\right)_{30\ kHz}$$

Their symbols are (- - -) and (—.—) respectively. Mean monthly rainfall (——) over Calcutta is also superimposed, (b) Monthly values of the significance ratio

of $\frac{A_{max}}{M_{min}}$ (- - -) and $\frac{A_{min}}{A_{min}}$ (—.—)

can be marked clearly in these records. The ratio of afternoon maximum to morning minimum (A_{max}/M_{min}) as well as the ratio of afternoon minimum to morning minimum (A_{min}/M_{min}) for all the days for which the record was clearly available have been taken into account. The mean monthly values of these ratios are then calculated and thereby the three months' running average values have been obtained for a two years' period to get the seasonal variations at 10, 20 and 30 kHz.

Physiologically, the response of the human ear to a noise is known to be logarithmic. So, the ratio of the noise levels of atmospherics at afternoon hours to that at the morning minimum in dB unit as considered here, is representative of the ratio of interference levels of noise monitored by audio

reception. This has been done with a purpose to examine the factor by which the noise level of atmospherics at afternoon maximum and late afternoon minimum originating mostly from local sources has changed with reference to the morning minimum level of atmospherics. In fact, the interference was also monitored aurally during the recording of IFIA.

The monthly variations of the ratios are found to be more regular between 10 and 20 kHz than between 20 and 30 kHz. The mean values of the two ratios at 10, 20 and 30 kHz is shown in Table 1.

It is seen from Table 1 that the levels of afternoon maximum and late afternoon minimum of atmospherics are greater than the, morning minimum
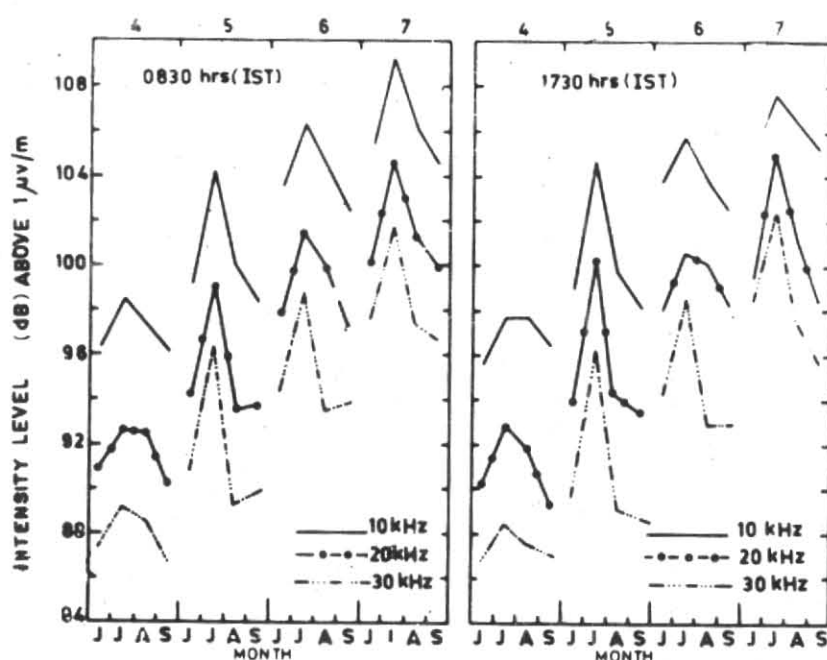
Fig. 2. Variations of the intensity level of atmospherics for various cloud amounts (okta)

in the VLF.band by a mean value of about 1.36 and 1.11 respectively. The monthly difference of A_{max}/M_{min} at 10 and 30 kHz as well as that of A_{min}/M_{min} at the above two frequencies have been plotted in Fig. 1 (a). These two frequencies, being the extreme values out of the three TRF (Tuned Radio Frequency) receivers constructed for the present observations, are chosen for plotting the monthly difference as well as for the significance ratio (Fig. 1(b). The test of significance (t) has been calculated by using the usual mathematical relation (Croxton and Cowden 1964),

$$t = \frac{\bar{x}_D}{\sigma_{\bar{x}_D}} = \frac{\bar{x}_D}{\frac{\hat{\sigma}_D}{\sqrt{N}}} \qquad (1)$$

where,

$$\bar{x}_D = \frac{\sum D}{N}$$

$$\hat{\sigma}_D = \sqrt{\frac{\sum D^2}{N-1} - \frac{(\sum D)^2}{N(N-1)}} \qquad (2)$$

Here D is the difference between the two mean values of a pair and N is the number of samples for which $\sum D$ is calculated. In our analysis, three months' running average value of atmospherics has been considered for the central month. Hence $N = 3$ and D is the differnce between the monthly mean values of atmospherics at 10 and 30 kHz. From each

TABLE 1

Mean value of A_{max}/M_{min} and A_{min}/M_{min} at 10, 20 and 30 kHz

Frequency (kHz)	Mean	
	A_{max}/M_{min}	A_{min}/M_{min}
10	1.42	1.17
20	1.36	1.12
30	1.29	1.05

of the three pair of values giving $\sum D$, the significance ratio (t) has been calculated for the central month using Eqn. (1). The level of significance (p) is then obtained from a knowledge of significance ratio (t) and degrees of freedom (n). The mean monthly rainfall over Calcutta obtained from the local meteorological observatory, Dum-Dum, averaged over 30 years, has also been superimposed in Fig. 1. The figure clearly indicates that the differences are sufficiently small during the period of heavy rainfall (June to September) and vice versa. Next, the monthly values of the level of significance of A_{max}/M_{min} and A_{min}/M_{min} have been calculated considering the double degrees of freedom $(n = N - 1 = 2)$. The results are given in Table 2.

It appears from Table 2 that the level of significance of atmospherics is comparatively high
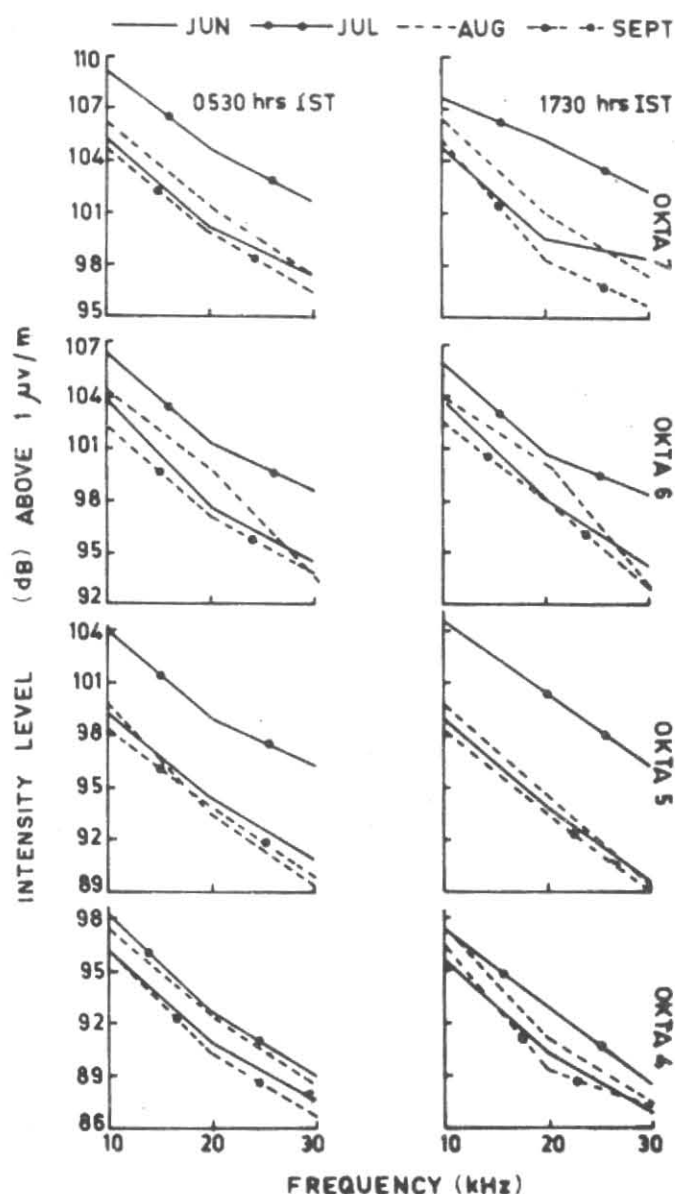
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Fig. 3. Frequency spectra of IFIA for 10, 20 and 30 kHz corresponding
to different cloud magnitudes during June-September

during the monsoon months for both the cases A_{max}/M_{min} and A_{min}/M_{min}. The smaller difference of A_{max}/M_{min} or A_{min}/M_{min} between 10 and 30 kHz, during the heavy rainy period, in association with low significance ratio and high level of significance, suggests that the test of significance may provide a valuable information regarding the precipitation pattern as well as the nature of the local sources.

3. Field intensity level of atmospherics and cloud magnitude

The field intensity level of atmospherics at the two specified hours have been considered with the cloud amount in okta. The occurrence of 8 okta is very rare and also the amount of okta below 4 does not sharply distinguish the intensity level of atmospherics. The variations of the intensity level with cloud amount for okta 4, 5, 6 and 7 have been plotted in Fig. 2. In this figure different monsoon months and frequencies, *viz.*, 10, 20 and 30 kHz have been considered. The variations of the intensity level in dB with cloud amount have been examined for both 0830 and 1730 hrs (IST).

Important results obtained from this analysis are the following :

(*i*) The variation of the field intensity level with cloud amount in okta is very systematic and regular
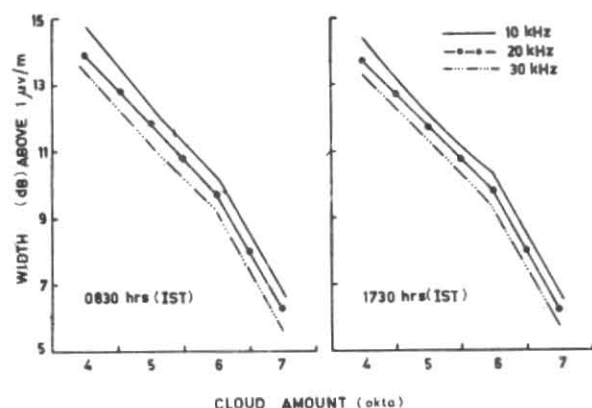
Fig. 4. Width of the field intensity level of atmospherics for different cloud amounts (okta) at 10, 20 and 30 kHz

for all the curves for both morning (0830 hrs IST) and evening (1730 hrs IST) observations.

(*ii*) The field intensity level exhibits highest value at 10 kHz, intermediate at 20 kHz and least at 30 kHz. Also, there is a variation of the field intensity level in different months showing a peak value in July for all the distributions of cloud amount.

(*iii*) At the onset of the monsoon during June-July there is a tendency of an enhancement of the field intensity level while inbetween the latter two months (August-September) the noise level appears to come down.

(*iv*) With the increase of cloud amount the field intensity level increases.

3.1. *Frequency spectrum*

The monthly mean of the field intensity level of sferics at the two specified times 0830 and 1730 hrs (IST) is plotted against the frequency in Fig. 3 for different cloud amounts in the monsoon months. It is apparent from the figure that: (*i*) the variation of the intensity level between 10 and 20 kHz is more regular than that between 20 and 30 kHz (*ii*) the field intensity level of sferics decreases with the increase of frequency from 10 to 30 kHz and there is a month-to-month variation of the level, the nature of which is nearly repetitive for both 0830 and 1730 hrs (IST); (*iii*) the rate of fall of the field intensity level with frequency can also be determined from the slope of the line between 10 and 20 kHz and from that between 20 and 30 kHz for different monsoon months. It is seen that the slope is much lower in 20-30 kHz range and increases in 10-20 kHz range and (*iv*) the field intensity level at both the

TABLE 2

Mean level of significance for different months averaged over two years

Month	Level of significance	
	A_{max}/M_{min}	A_{min}/M_{min}
October	$.10 < p < .12$	$.10 < p < .12$
November	$.13 < p < .15$	$.07 < p < .09$
December	$.12 < p < .14$	$.03 < p < .05$
January	$.06 < p < .08$	$.02 < p < .04$
February	$.04 < p < .06$	$.04 < p < .06$
March	$.06 < p < .08$	$.05 < p < .07$
April	$.07 < p < .09$	$.05 < p < .07$
May	$.11 < p < .13$	$.07 < p < .09$
June	$.26 < p < .28$	$.29 < p < .31$
July	$.56 < p < .58$	$.70 < p < .72$
August	$.55 < p < .57$	$.74 < p < .76$
September	$.26 < p < .28$	$.12 < p < .14$

hours increases prominently with an incease in the cloud amount.

3.2. *Cloud distribution and the width of IFIA*

The day-to-day variations of the width of the atmospherics level with reference to different cloud amounts in okta have been taken into account for all the frequencies during the monsoon months at 0830 and 1730 hrs (IST). In Fig. 4 average values of the width of IFIA have been plotted against the cloud amount (okta) for the frequencies 10, 20 and 30 kHz. The figure, interesting enough, reveals that the width decreases with increase in cloud amount. When the cloud amount is very high, like 7 okta, the width is reduced sharply. This is true for all the three frequencies and for both the observational hours.

4. Discussion

It is now fairly well reported that the amplitude properties of electric fields at a place are due to the lightning discharges around the observing station (Nakai 1977). The greatest value of A_{max}/M_{min} and A_{min}/M_{min} as noticed over Calcutta during the monsoon months in comparison to that of the other

seasons of the year appear to originate mainly from near sources of lightning at such times. May to October is the principal rainy period in this region when sky is often covered by cumulonimbus and nimbostratus clouds and nearly 75% of the annual rainfall occurs during this period. Dhar and Ramachandran (1970) have calculated the mean rainfall over Calcutta for each clock hour of the day, for each of the rainy months, which shows that rainfall generally occurs in the afternoon hours between 1300 to 1900 hrs (IST).

The comparatively high values of afternoon maximum, noticed during rainy months in the diurnal pattern of IFIA, seem to be closely associated with the diurnal pattern of rainfall during this season. It has further been noticed in Fig. 1 that the difference of the ratios decreases considerably with the increase of precipitation, when the intensity levels at 10, 20 and 30 kHz are close together.

During the localised cloud activity the intensity level in atmospherics record attains a higher value, while, when such cloud activity disappears, the intensity level comes back to its earlier condition. With increase in cloud amount (okta), the intensity level exhibits a further increase due to the discharges from the assemblage of nimbostratus clouds over and around the observing station as the VLF receivers used for IFIA measurements having large dynamic range, respond to strong local electromagnetic field variations, suppressing the effect of weak distant fields. The characteristics in

the variations of IFIA at Calcutta as found in the present analysis may, therefore, be assumed to originate from the local active cloud sources during this season. The finding supports the earlier report of the monthly variations of hourly median values of IFIA over Calcutta, which showed that while the median values are higher during the summer months than in the winter, their maximum values lie in the monsoon months (Bhattacharya and Bhattacharya 1985).

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