Atmospheric Radio Noise Field Strengths for the Central & Western Regions of India

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A comparison between the seasonal variations of thunderstorm-days, distributed regionally inside the landmass of India, with those of atmospheric radio noise field strengths (ARN-FS) measured in locations inside the corresponding regions, indicates that the two have similar trends of variations particularly in the Northern and Eastern regions of India. The findings have been utilized, as a basis for estimating the values of ARN-FS for the Central region for which no measured values of ARN-FS are available. The same procedure has been adopted to estimate values of ARN-FS for the Western region for which some limited measured values of ARN-FS have been reported.

1. Introduction

The atmospheric radio noise field strength (ARN-FS) has long been recognized as an important parameter for planning and designing any kind of radio communication service. A semi-empirical relation involving source distance, ionospheric absorption and frequency of observation was earlier formulated to estimate its value below 30 MHz. While both the calculated and the measured values of ARN-FS show similar variations with frequencies for different time-blocks and seasons for the Northern and Eastern regions of India, certain anomalies were observed for the Southern region. They are in the form of enhancements at certain frequencies. These were considered to be due to the frequent occurrence of sporadic E in the equatorial region of India.

No measurement of ARN-FS has been reported so far for the Central region of India. For the Western region, however, some limited values of ARN-FS measured at Poona (18°19'N, 73°33'E) are available; but they are, firstly, not sufficient in number and secondly, not in suitable form for the application of the semi-empirical formula in estimating the values of ARN-FS for all the seasons and time-blocks for this region.

In this paper, an attempt has been made to correlate the region-wise seasonal variations of thunderstorm activities with those of the values of ARN-FS measured at representative locations in different regions (wherever available) and then applying the findings to estimate the values of ARN-FS for the Central and Western regions of India.

2. Parameter for Comparison

The measured values of ARN-FS that are available for different seasons, Winter (December-February), Spring (March-May), Summer (June-August) and Autumn (September-November) and time-blocks (0800-1200, 1200-1600, 1600-2000 and 2000-2400 hrs IST) are generally in the frequency range 2.5-9.5 MHz. Assuming that at these frequencies, the source-distance, for which propagation condition is optimum, is regional, i.e., 800-1000 km, the seasonal variations of the values of ARN-FS in different regions should be a function of region-wise seasonal variations of thunderstorm activities.

For the purpose of comparing these variations of ARN-FS and thunderstorm activities, a thunder-flash (which is the radiator of atmospheric radio noise) would have been a very desirable parameter. But it is very difficult to estimate, even statistically, the average number of thunder-flashes occurring over a region, within a given period, month or season. On the other hand, the average number of thunderstorm-days in a given region, within a month or a season, can comparatively be easily determined. This parameter, when observed over a long period at random locations within a given region, is treated as a statistical unit of a randomly varying population and will have a relation of the form:

\[ N = K \cdot T \]  \hspace{1cm} (1)

where \( K \) is a constant of proportionality, \( N \) is the value of ARN-FS for a given frequency, period and season in a given region and \( T \) is the statistically averaged number of thunderstorm-days for the corresponding season and the region. The constant of proportionality, \( K \), can be eliminated if ratios are taken for comparison.

In this work we have taken for comparison, the ratios of values of ARN-FS and the ratios of number of thunderstorm-days for any given season with re-
ference to those for the winter. This is because in this season, generally the values of ARN-FS are at their lowest.

3. Division of Indian Landmass into Five Regions

For the assessment of $T$ values region-wise, Indian landmass may be divided, to some extent arbitrarily but mainly on considerations of the map showing the lines of equal average annual number of thunderstorm-days, into five zones or regions, viz. North, East, South, Centre and West. This is illustrated in Fig. 1. The locations where measurements of ARN-FS have been carried out and have been considered in this study are Delhi (28°35'N, 77°05'E), Guwahati (26°10'N, 91°40'E), Vizag (17°41'N, 83°18'E) and Trivandrum (8°29'N, 76°57'E); and these can be treated as the representative stations for some of the different regions listed above.

The Meteorological Department of India through its observatories situated in different parts of the country have collected a vast amount of data on the frequency of thunderstorm activity days for various times of the day and year for a long time. On request some of these data were obtained in respect of about 50 places located in different regions. From this, the value of number of thunderstorm-days for a particular season of a region has been obtained by taking the average of the values of all the stations situated in that region for that season. The same procedure has been repeated for all the seasons and all the regions. The seasonal variations of $T$ thus obtained are shown in Fig. 2. Almost similar type of seasonal variation of $T$ has been obtained by Aiyar, although his $T$ values are higher than ours.

4. Correlation of Thunderstorm-days with ARN-FS

For the purpose of correlation, the ratios of values of $T$ for different seasons with that for winter ($T/T_w$) have been evaluated and are given in Table 1 for various regions.

Taking Delhi as a representative location in the Northern region of India, the seasonal variations of $N/N_w$ and $T/T_w$ for this region have been compared for “Day” and “Night”. The values of $N$ for “Day” have been obtained by taking the sum of values of ARN-FS for 0800-1200 and 1200-1600 hrs and that for “Night” by taking the sum of the values of ARN-FS for 1600-2000 and 2000-2400 hrs. The results of comparison are illustrated in Fig. 3 where smoothed curves are plotted. For the sake of convenience, the seasons have been shown in slightly altered sequence. It is seen from Fig. 3 that both $N/N_w$ and $T/T_w$ have similar trends of variations for “Day” and “Night” for all the frequencies of measurements.
Almost similar results though not as exactly as shown in Fig. 3 have been obtained for the Eastern region with the values of ARN-FS measured at Gauhati, a representative location in this region.

For the Southern region, as already stated, measurements of ARN-FS are available for two stations: one is Trivandrum, situated at the extreme Southern end and the other is Vizag, located at the extreme Northern end of this region. While anomaly in the form of enhancement around 3·5 and 7·0 MHz has been observed in the former station, in the latter it is almost absent. In view of this difference, and specially due to locational importance the values of \( N/N_w \) for Trivandrum have been compared with the values of \( T/T_w \) for the Southern region. Consistent with our previous observations, the anomaly is again noticed at frequencies around 3·4, 4·0, 6·0 and 7·0 MHz.

5. ARN-FS for Different Regions of India

From the analysis given in section 4, it appears worthwhile to examine the application of the \( T \) to \( N \) for any given region, season, frequency and time-block. For this purpose, the following procedure may be adopted.

If \( T_E \) is the number of thunderstorm-days inside (for example) the Eastern region of India, in a given season and if \( T_N \) is the same for the Northern region

\[
\begin{align*}
\text{East} & : T_E / T_N \\
\text{North} & : T_N / T_W \\
\text{Centre} & : T_W / T_N \\
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These observations indicate that one can be extended to estimate ARN-FS seasons, frequencies and time-blocks for other regions where the calculated or measured values are scarce or nil. Using the measured values of ARN-FS for the Central region, then in view of discussion given in Section 2, one can write:

\[ N_E/N_N = T_E/T_N \]  

where, \( N_E \) is the value of the ARN-FS for a given season, frequency and time-block for Gauhati (in the Eastern region) corresponding to \( T_E \) and \( N_N \) is the same for Delhi (in the Northern region) for the same season, frequency and time-block corresponding to \( T_N \). Since the values of \( N_N \) and \( T_E/T_N \) are available, \( N_E \) can be estimated. Fig. 4 shows a comparison of ARN-FS values thus estimated with the measured values for Gauhati (continuous lines) for different seasons, frequencies and time-blocks. Agreement is found to be good.

Similar procedure was adopted to estimate ARN-FS for the Southern region using Eq. (2) and the ARN-FS for different seasons, frequencies and time blocks and \( T_S \) for the same region. Agreement was much less. This is expected because the enhancement in the values of ARN-FS is caused by an agency different from thunderstorm activities.

Fig. 5—ARN-FS values estimated in this work for the Central region of India

These observations indicate that the procedure can be extended to estimate ARN-FS for different seasons, frequencies and time-blocks for other regions where the calculated or measured values are either scarce or nil.

Using the measured values of ARN-FS at Delhi, \( N_C \) have thus been obtained for the Central region. These values of \( N_C \) for different seasons, frequencies and time-blocks are shown in Fig. 5. Since no measurement of ARN-FS is available for this region, direct comparison with any measured values has not been possible.

Similar procedure was also followed to obtain values of \( N_W \) for the Western region. These are shown in Fig. 6. Some values of ARN-FS measured at Poona are available. But these are only during 1800-2300 hrs IST. So, for the purpose of comparison, our estimated values of ARN-FS for the time-blocks 1600-2000 and 2000-2400 hrs IST have been averaged and shown in Fig. 7 along with the measured values.
6. Conclusions

A correlation between the seasonal variations of the number of thunderstorm-days in a given region of India, with those of the measured values of ARN-FS for the corresponding region, has been obtained. On the basis of such correlation a procedure has been developed by which estimation of the values of ARN-FS for a given frequency, time-block and season for any given region of India is possible provided the number of thunderstorm-days for that region is available. Following this procedure, ARN-FS values are given for the Central region of India for which no measured or estimated data are available and for the Western region for which there are only limited data.

The ARN-FS values for the Northern, Eastern and Southern regions of India are available as have been reported earlier. With the values of ARN-FS for the Central and Western regions given in this paper, the entire landmass of India is covered for practical applications in planning any particular radio communication coverage.

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