REVIEW OF THUNDERSTORM ACTIVITIES IN INDIA FOR ANALYSIS OF LIGHTNING PERFORMANCE OF POWER LINES

M. Dixit, Ph.D. Student, V. Shostak, PhD, Docent
Igor Sikorsky Kyiv Polytechnic Institute, Department of Theoretical Electrical Engineering

Introduction. Lightning performance of overhead power lines includes analysis of related overvoltages and their comparison to characteristics of insulation. Lightning overvoltages at lines are fast-front transient voltages mainly caused by the impact of lightning strikes directly to lines and to ground or other objects in their vicinity. Lightning performance of power lines calculation is based on consideration of thunderstorm activity and lightning occurrence data (thunder hours T_h, thunder days T_d, ground flash N_g and strikes N_s densities, etc.) and statistical distributions of lightning parameters (probability distributions of return stroke current peak values *P(I)*, of current steepness values *P(S)*, etc.). These calculations can be done according special procedures, varied in some countries, for example, according to IEEE Std 1243-1997[1], CIGRE WG 33-01 [1, 2]. As authors interested to perform analysis for Indian utilities, it is required to overview available thunderstorm data for this purpose. India is exceptional with the availability of variety of climate zones such as hot-dry coastal, island, hilly, interior and oceanic [3]. For planning and management of power transmission, safe air navigation and safety against forest fires from lightning and lightning strike events, etc., the knowledge on frequencies of occurrence of thunderstorms in different parts of India and related lightning characteristics, is all the more essential [4].

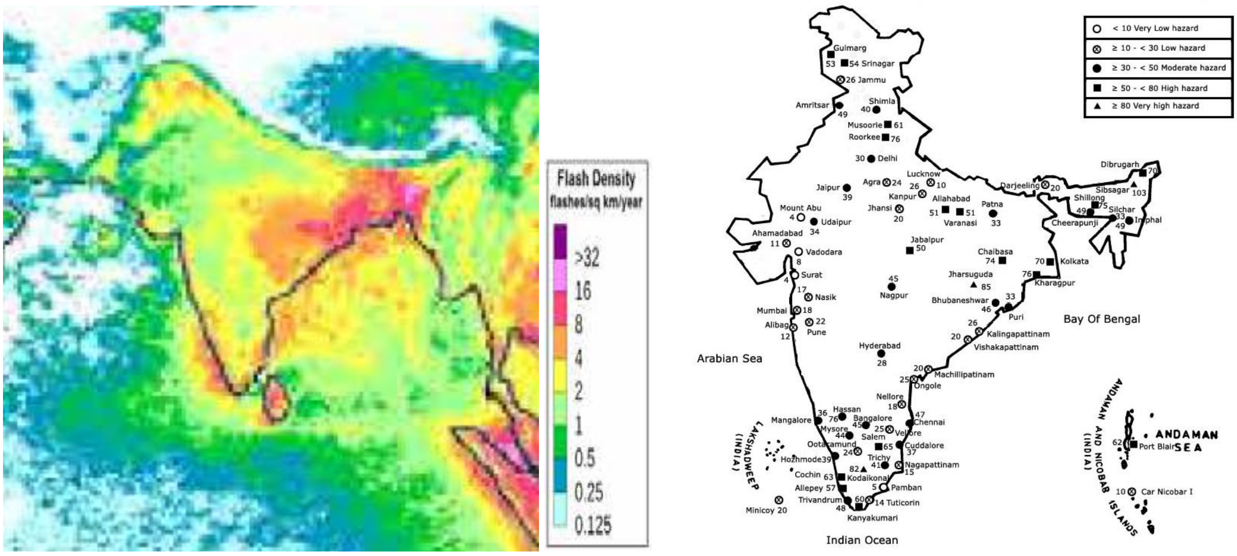
Aim of the Work. The aim of the work is to collect information on thunderstorm and lightning characteristics in India and process it for further analysis of power lines lightning performance.

Results and Discussion. In Indian topology, the climatic activity is studied on basis of longitude and latitudes, regions, and seasonal variations. The Indian annual thunderstorm days count is ranging from 1 to 103 as recommended by Indian standard IS 2309 [5]. The world lightning activity maps indicate that Indian region is having variation in thunderstorm days from about 20 at western coast to 40 at eastern coast [6]. These numbers correspond to the ground flash density (GFD) Ng (flashes$\cdot$km$^{-2}\cdot$year^{-1}), which can be calculated by different formulas for different countries. In the paper, it is calculated by Equation 1 as per IEEE Std 1243-1997 [1]:

$$N_g = 0.04 T_d^{1.25} \tag{1}$$

The measurement of data was done in past using radars and weather stations located in different ranges of distances. After the invention of satellite technology, the data were recorded with the help of remote sensing centre. The advanced progress in optical and image processing field resulted in the measurement task become simpler. Some data considered for this paper indicate that for different years these may vary in the ranges of 0.6 to 1.13 [3, 7]. The data were obtained from Indian observatory stations and Optical Transient Detector system (OTD). The combination of OTD and Lightning Imaging Sensor (LIS) on board of the Tropical Rainfall Measuring Mission (TRMM) satellite are used in recent studies. The calculation range are based on optical detection, hence, it is required to have regional database to relate the optical data with the ground measured values [3, 7].

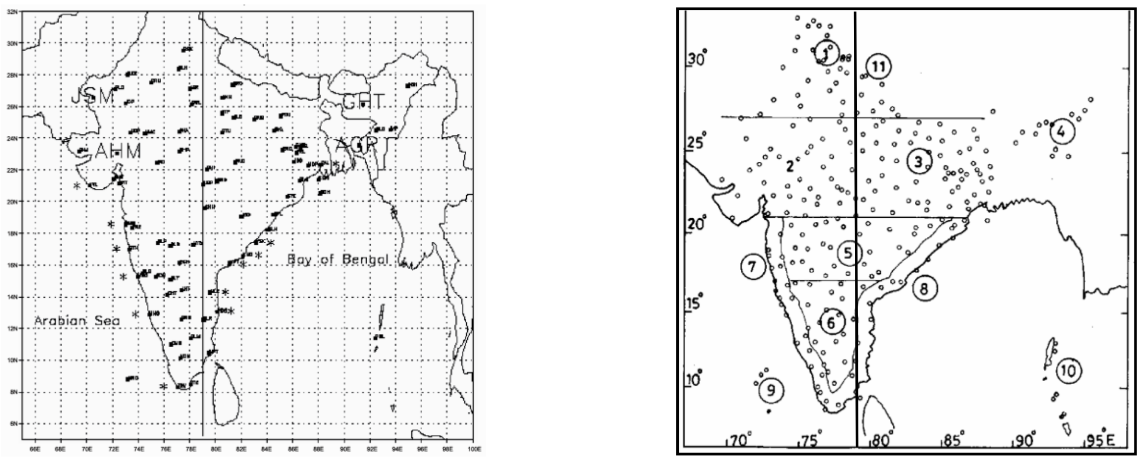
The climatological data of flash density (N_g) [8] and annual number of thunderstorm days (T_d) [9] for Indian territory can be used for study constructed on latitudinal (7° N - 33° N) variation as shown in Fig. 1.



a) [8] b) [9]

Figure 1 – Flash density and thunderstorm days patterns in India [8, 9]

The geographical areas of Eastern region (ER), Western region (WR) of India were selected for investigation separated by vertical line as shown in Figure 2a and 2b [3, 7]. In Figure 3b, Eastern region is combined of subregions 5, 6, 7, 9 and Western region – of subregions 3, 8. The data originally were taken from India Meteorological Department (IMD), published in 1999 [4, 7].



a) [3] b) [7]

Figure 2 – Indian regional maps and locations of weather stations [3, 7]

The data from [3, 7] were additionally analyzed by the authors and results are presented in Fig. 3. One can observe that the annual mean of lightning flash count of ER is noticeably higher than that of the WR in monsoon season. The winter season shows almost same amount of variation. Only during the months October–December, the flash count of WR is higher than that over ER.

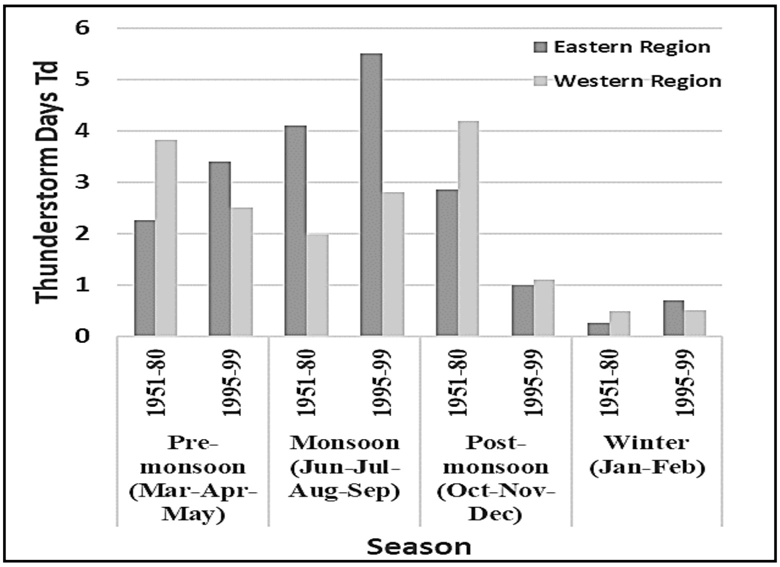


Figure 3 – Seasonal variation of thunderstorm days based on studies described in [3, 7]

The changes in thunderstorm activities are remarkable in both regions. Seasonal variations numbers and mean values for total period of T_d and calculated N_g are shown in Table 1. The seasonal thunderstorm days have significant values in pre-monsoon and increasing more in monsoon. For winter the values are comparatively lesser as compared to total count.

Table 1 – Thunderstorm days (T_d), seasons/total, and GFD (N_g) averaged for study periods of 1951-1980 and 1995-1999, for ER and WR, based on data from [3, 7]

Region	T_d					N_g for total period*
	Pre-monsoon	Monsoon	Post-monsoon	Winter	For total period	
ER	2.83	4.81	1.93	0.49	10.06	0.72
WR	3.16	2.39	2.65	0.50	8.7	0.60

* Related to data obtained by OTD

More recent study of lightning activity was conducted over the Arabian Sea and the Bay of Bengal of Indian coastal region using monthly satellite-based lightning flash count grid data for a 10-year period (1998–2007) [10]. It was found the annual variation in flash rate density (flashes$\cdot$km$^{-2}\cdot$year^{-1}) with the first peak occurring in May and the second in October. The amplitude of the first maximum (May) observed to be 11.5 for the Arabian Sea and 28 for the Bay of Bengal. The second maximum (October) was observed as 9 for the Arabian Sea and 10 for the Bay of Bengal. The lightning activity shows a minimum range of flash rate density between 0.5 to 1 in December, January, and February [10].

Conclusion. The lightning activity data are mainly gathered with the meteorological radars and ground stations, Optical Transient Detector (OTD) system, Lightning Imaging Sensor (LIS), and Lightning Detection Networks (LDN). From the reviewed observations it can be resolved as follows:

1. The parameter of averaged annual thunderstorm days available in Indian standard IS 2309 is ranging from 1 to 103. This corresponds to maximum level of N_g up to 9.2 flashes·km^{-2}·year^{-1} with variation limits at this level from 4 to 20 [5].
2. Data obtained from ground based remote observation networks (like Vaisala) give N_g values for the ER in the range of 4 to 16 and in some areas of the North-Eastern region it is raising up to 32. For the WR, it has variation from 4 to 8 in South-West coast and decreases to 2 in the Arabian Sea.
3. From some optical studies, the annual mean of lightning flash count and ground flash density of Eastern region (ER) is found larger by 20% (0.72/0.60=1.20) than that of the Western region (ER). In monsoon season it is twice larger (4.89/2.39 = 2.01). The calculation of ground flash density N_g from satellite optical observations is not always accurate and requires additional validation for different regions.
4. Available data on lightning activity over different parts of India are not enough complete. Measurement techniques based on satellites, such as OTD and LIS, have limitations in obtaining N_g. Thus, for India there is a need in development of modern LDN and related studies on lightning characteristics. Presently, for statistical distributions of lightning current parameters can be taken the approaches from IEEE and CIGRE Guides. Further studies are required on thunderstorm days, ground flash density and current parameters statistical distributions for different locations, which will be supportive in performing analysis for Indian power utilities.

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