

Investigating the Relationship between some Thunderstorm Parameters and Ground Flash Density.

J.O. Adepitan, M.Sc. and F.O. Ogunsanwo*

Department of Physics and Telecommunication, Tai Solarin University of Education, Ijagun, Ijebu, Nigeria.

E-mail: olufemiabisola@yahoo.com*
godif07@yahoo.com

ABSTRACT

Lightning is one of the major causes of outages on electric distribution and transmission lines as well as telecommunication network. Ground flash density is a major lightning parameter in estimation of outage density rates. This can be determined from data collected from lightning location system. In the absence of lightning location system, thunderstorm parameters (thunderstorm days and thunderstorm duration) can be used to get an approximation of the ground flash density.

This work focused on developing relationship between (i) thunderstorm parameters on one hand and (ii) thunderstorm parameter and lightning parameter. Data for some thunderstorm parameters (thunderstorm days and thunderstorm duration) for five years (2006-2010) were collected for three meteorological stations in south-west of Nigeria. Relationship was derived between thunderstorm duration and thunderstorm days. Relationship was compared with the relationship between ground flash density and thunderstorm days obtained for some other tropical environment. A direct linear relationship was established between the ground flash density and the thunderstorm duration. A power relationship was developed between thunderstorm duration and thunderstorm days.

(Keywords: thunderstorm days, thunderstorm duration, ground flash density, lightning)

INTRODUCTION

A storm can be classified as thunderstorm only when thunder (the sound emitted by rapidly expanding gases along the channel of lightning discharge) is heard. The main parameters of thunderstorm characteristics are (i) thunder days (ii) thunderstorm duration, and (iii) thunderstorm

hours. The thunder day is the calendar day on which thunder is heard at a station.

Lightning can be referred to as a discharge of atmospheric electricity, accompanied by a vivid flash of light, commonly from one cloud to another, and sometimes from a cloud to the Earth. The sound produced by the electricity in passing rapidly through the atmosphere constitutes thunder. Lightning incidence or frequency of lightning discharge in an area or region can be determined by the thunderstorm days in that area. Whereas, ground flash density (Ng) is defined as the number of lightning flashes per km² and year.

Where ground flash density (Ng) data from lightning location systems are not available, thunderstorm day or thunder hours can be used to get a rough approximation of ground flash density. Information on annual thunderstorm duration is of great interest to many different groups such as power generation facilities, construction companies, and Federal and local government agencies.

A comprehensive climatology of thunderstorm duration is required to provide accurate information for all areas in Nigeria. Previous studies showed the relationship between thunderstorm duration and ground flash density (MacGorman et al., 1984; Changon, 1985) and the number of the thunderstorm events compared with the ground flash density (Changnon, 1993; Changnon et al., 1988). Each of these studies used observed records of thunder overhead to determine the thunderstorm duration.

Several factors can lead to errors including increased background noise at the location, observers being too occupied with other aspects of the storm to accurately record when the thunder ceased, and a tendency to include thunder in the observations when lightning is

visible, but distant. These are understandable limitations in the thunder data and can misrepresent the duration of a thunderstorm. In this study, we want to determine the relationship between the thunderstorm duration and thunderstorm days as well the ground flash density in the tropical zone of the south-western Nigeria.

METHODOLOGY

Thunderstorm days with corresponding thunderstorm duration for three meteorological stations: Ikeja (Lat. 6°35'N, Long.3°20'E), Akure (Lat.7°16'N, Long. 5°10'E), Ibadan (Lat.7°21'N, Long.3°51'E) in south-west Nigeria were collected for five years from Nigeria Meteorological station (NIMET). The thunder days per year with corresponding thunderstorm duration, measured in hours were determined for all the stations. The ratio of thunderstorm duration to thunderstorm days for each year was also determined.

A graph of the thunderstorm duration was plotted against thunderstorm days, making use of Excel package. The best trend line was thereafter determined.

RESULT AND DISCUSSION

The annual thunder day with corresponding thunderstorm durations from 2006 to 2010 were obtained as shown in Table 1 below where T_d is the thunderstorm days and T_h is the thunderstorm duration per year. The annual thunderstorm duration data when plotted against the corresponding thunderstorm days shows a high degree of fitness of value $R^2 = 0.9524$ and the annual average duration, K, of one storm to the other varies between 3.2 and 6.2.

However, from the curve obtain power law relationship develop is said to be of the nature

$$T_h = 3.0511 T_d^{1.103} \quad (1)$$

As it has been stated earlier that where ground flash density (N_g) data from lightning location systems are not available, thunderstorm day or thunder hours can be used to get a rough approximation of ground flash density.

Comparing Equation (1) with the value obtain for the ground flash density in other tropical region

like Mexico and Brazil, it showed that there was consistency in the value of ground flash density around the tropical region with the one obtained for that of tropical region of south-west in Nigeria as shown below:

$$N_g = 0.024T_d^{1.12} \quad \text{Mexico} \quad (2)$$

$$N_g = 0.0030T_d^{1.12} \quad \text{Brazil} \quad (3)$$

Table 1: The Annual Number of Thunderstorm Days and Thunderstorm Duration.

Thunderstorm days (T_d)	Thunderstorm duration (T_h /h)	Annual average duration (K)
80	330	4.1
70	291	4.2
55	216	3.9
62	313	5.1
64	400	6.2
11	43	3.9
26	146	5.6
19	74	3.9
27	97	3.6
12	52	4.4
48	229	4.8
34	177	5.2
42	182	4.3
24	102	4.2
16	52	3.2

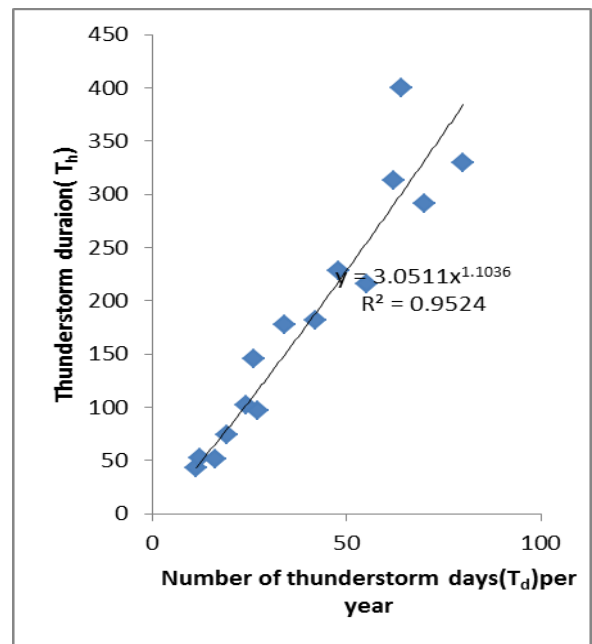


Figure 1: Relationship between the Annual Value of Thunderstorm Duration and the Number of Thunderstorm Days.

If thunderstorm duration as a function of thunderstorm day is having the same power of T_d with the N_g , then linear relationship exist between them.

According to Torres (2003), ground flash density N_g in Equations 2 and 3 are applicable to tropical regions located within latitude range of (2-10⁰N) which agreed with the location used in this study.

CONCLUSION

From the results obtained, it was shown that the power law links the thunderstorm duration with the number of thunderstorm days. A linear relationship was established between thunder storm duration and lightning flash density.

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