ISSN 2347 - 3983
Volume 8. No. 1.1, 2020
International Journal of Emerging Trends in Engineering Research
Available Online at http://www.warse.org/IJETER/static/pdf/file/ijeter2681.12020.pdf
https://doi.org/10.30534/ijeter/2020/2681.12020

Unravel the extent of the existence of positive ground flash in Malaysia

Atifa Faaidha Munauwer[1,3], Zikri Abadi Baharudin *[2], Mohd Ariff Mat Hanafiah[2], Maslan Zainon[2], Syed Najib Syed Salim[2], Mazree Ibrahim[2]

[1]Department of Electrical and Electronics Engineering, Xiamen University Malaysia, Sepang, Malaysia, atifa.munauwer@xmu.edu.my, 013-6362874

[2] Fakulti Teknologi Kejuruteraan Elektrik & Elektronik, Universiti Teknikal Malaysia Melaka, Zikri@utem.edu.my, +6(06)5552365

[3] Fakulti Kejuruteraan Elektrik, Universiti Teknikal Malaysia Melaka

ABSTRACT

Positive cloud-to-ground flash (+CG) in tropic countries such as Malaysia is not common. However, some studies in Malaysia reported that the +CG in Malaysia occur more than the nominal percentage of 10 %. The uncertainty feature as mentioned above motivates the authors to stratify the +CG from 135 electric field data acquired in two different thunderstorms recorded in Melaka, Malaysia. To ensure consistency of the measurement, the accurate stroke count technique that widely have been used by majority lightning investigators was utilized in Universiti Teknikal Malaysia Melaka measurement station. The electric fields were recorded with nanosecond resolution using High Definition Lecroy. The signal of lightning study within few Hz to tens of MHz, were detected by the combination of parallel plate antenna and voltage follower amplifier. In summary, negative cloud to ground flashes (-CG), +CG and cloud flash (CC) were found to have 123(91%), 6 (4.44%) and 6 (4.44%), respectively. Further, comparison study has shown that there is no consistency in previous studies in Malaysia and Indonesia and lead to uncertainty. Overall, it is extremely important to all researchers in tropical region to realize that the positive lightning has to be scrutinized carefully and still open into a big question in presenting a proper manner.

Key words: Positive Lighting, Cloud to Ground Flash, Lightning

1. INTRODUCTION

Lightning was defined by [1] as a transient, high-current electric discharge whose path length is commonly measured in kilometers. As some region of the atmosphere gain a large electric charge, air breakdown will be initiated thus producing a lightning. It is basically a massive electrostatic discharges caused by unbalanced electric charges in the atmosphere, resulting in a strike and accompanied by the loud sound of thunder. It is crucial to comprehend the lightning behavior and its capability to cause injuries or even death by direct or indirect strikes.

Based on [2] and other researcher mentioned in this paper, the most common sources of lightning is the cumulonimbus. The structure of the thundercloud normally is a tripolar electrostatic where the top part of the cloud is the main positive charge, the main negative charge of the cloud is in the middle, and there is another additional positive charge pocket that is at the bottom below the main negative. However [3] stated that the typical charge structure of the thundercloud seems to be a nonconductive factor for positive lightning. In order to produce positive lightning, there are six investigated conceptual cloud charge configurations and scenarios, these scenarios were found to be possible for the formation of +CG. The six conceptual cloud charge configurations and scenarios are Tilted Dipole, Positive Monopole, Inverted Dipole, Unusually Large Lower Positive Charge Region, Negative In-Cloud Leader Channel Cutoff and Branching of In-Cloud Channel.

Till date, there are several forms of lightning discharges observed on our planet, those discharges are air discharge, intra-cloud discharge, cloud-to-ground (CG) discharge, and cloud-to-cloud discharge. CG flash is the most common type of lightning and it has gain interest in many researchers compared to other forms of lightning discharges. It is because CG discharge research has more practical uses such as the way it causes injuries and/or death to humans, disruption to the power supply of humans, disturbance of the communication systems, and the cause of some forest fires. On another note, Cloud-to-cloud and cloud-to-air discharges are less common as compared to intra-cloud or CG lightning.

A CG flash occurs between the charge centers of the cloud and the ground resulting in transfer of charge from cloud to ground. There four types of CG discharges which are downward negative lightning, upward negative lightning, downward positive lighting and upward positive lightning. -CG flashes transports negative charges from cloud to ground while a +CG flash will bring positive charges from the cloud

to the ground. Lightning protection researches as well as atmospheric physics both rely significantly on these two flashes.

+CG in general carry a larger amount of current and transfer more electrical charges compared to -CG. Based on [4] the highest recorded current and the largest charges transfer to ground is associated with +CG flash. Hence, with regards to the characteristics of +CG flashes, extra protection procedures are recommended in lightning protection standards.

In most studies such as [5][6][7] shows that the occurrence of positive ground flashes is only about 10% of the total CG flashes. However, during colder seasons or weather such as nearing the end of a thunderstorm, +CG can be much more common. Moreover, there is difficulty in the collecting of large samples of the electric fields produced by +CG, due to the scarcity of +CG flashes. Hence, +CG investigations and research are often controversial and misinterpreted.

Based on [8] due to scarcity of data, +CG lightning studies in Malaysia and Indonesia is minimal even though Malaysia is located near the equator. In 2018, [9] has done an investigation on the occurrence of +CG lightning in UMP Pekan, Malaysia .They presented the occurrence of both +CG lightning and -CG according to data obtained from Malaysia Meteorological Department (MMD). The MMD has and uses a surveillance system named SAFIR 3000 that has eight sensors installed around Peninsular Malaysia. A VHF interferometry technique has been used to sense and record lightning activities. A total of 201,296 events has been recorded within 100 km radius from the midpoint at UMP Pekan. 157,200 events or 78.09% was -CG lightning while 44,096 events or 21.91% was +CG lightning.

Another study on the +CG flash in different meteorological conditions has been done in 2015 by [10]. The measurement was done from November to Febuary 2012 during monsoon period at the Observatory, Universiti Teknologi Malaysia (UTM), Johor. The vertical component of the electric field was collected using parallel plate antenna that is connected to a digital oscilloscope (DSO) via a buffer circuit. Software such as LabView and Matlab were used to monitor and analyze the recorded signals. Out of 2,289 lightning strikes, a total of 48 or 2.10% of them were identified successfully as +CG.

[11] presented a study on unique stroke multiplicity of +CG in Malaysia. Measurements has been done on October 2013 in Universiti Putra Malaysia (UPM). The field measurements were done similar to the studies by [10] in the previous paragraph, where a parallel plate antenna was connected to a recording system through a buffer circuit. Out of the total 172 lightning ground flashes recorded and analyzed, 57 or 33.14% of them were found to be +CG.

In 2018, [12] has done a CG lightning observation in Malacca, Malaysia . The measurement was done from a single storm on 14 September 2016 and 102 positive lightning has been recorded. The data was recorded by using wideband fast and slow electric field antennae system, magnetic field sensor and a VHF sensor.

The characteristics of positive flashes in the tropics of Indonesia were presented by [13] and [14] in 2017. The data analyzed in this study were recorded on 31 thunderstorms from May to October 2014 by using a circular flat-plate parallel antenna that was connected to buffer electronics and digitized with a 12-bit digitizing oscilloscope. A total of 11,392 lightning events was recorded by the measurement system and 77 or 0.68% positive cloud to ground lighting has been detected.

In general, based on above mentioned studies, we found that +CG lightning flash has not been fully understood in this region as some researcher reported that the +CG in Malaysia occur more than the nominal percentage of 10 %. Therefore, this paper is a stepping stone to create awareness to all researcher in this region that a scrutinize study on positive lightning is crucial especially in term of identifying the characteristics of the electric field involved in a lightning event. The investigation of +CG lightning flash in this paper is obtained from two thunderstorms in Melaka, Malaysia.

2. ELECTRIC FIELD MEASUREMENT

The experimental setup for this investigation measurement were adapted from [15] and was recorded at Universiti Teknikal Malaysia Melaka (UTeM), Malaysia (Latitude: 2°16’39.8586’’N, Longitude: 102°16’30.72’’ E). Figure 1 shows the schematic diagram of electric field measurement. A parallel flat plate antenna was used to measure the fast electric field and slow electric field.The parallel flat plate was connected to a 1.5 meter metal rod and then connected to the buffer circuit through a 60cm RG58 coaxial cable. Buffer circuit act as a driver to control the signal between antenna and transient recorder through the coaxial cables. The transient recorder operated at a 300ms pre-trigger mode. Decaying time constant was set to 15ms and the rise time of the broadband antenna system (fast field) for the step input pulses should be less than 30ns. The buffer circuit was then connected to a four channel oscilloscope by using a 10m RG58 coaxial cable. Total length recorded waveform was 2s with 12.5 MS/s sampling rate setting. The trigger level was set between 50mV and 500mV for the far flashes, and 500 mV to 2V for the close flashes to ensure both polarities were captured. The output signal was then connected to the computer and the waveforms was analyzed in detail by using LABVIEW software.

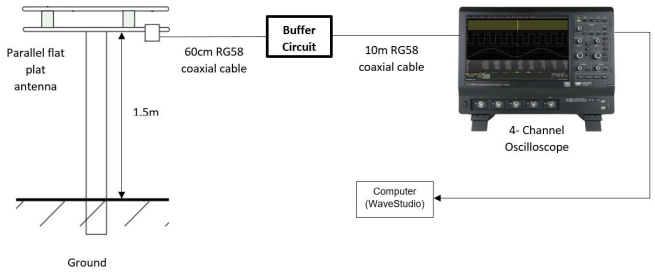

Figure 1: Schematic diagram of the electric field measurement

3. RESULT AND DISCUSSION

A total of 135 electric field data from two different thunderstorm events were investigated. The findings of the statistical results showed that 123(91%) were -CG flashes, six (4.44%) +CG lightning, and six (4.44%) cloud activity. The average number of strokes per flash in this study is 1.3. Five (83%) out of six +CG, the first leader-return stroke sequence was not preceded by in-cloud discharge activity. Figure 2 shows an example of positive cloud to ground flash recorded on 18 October 2018.

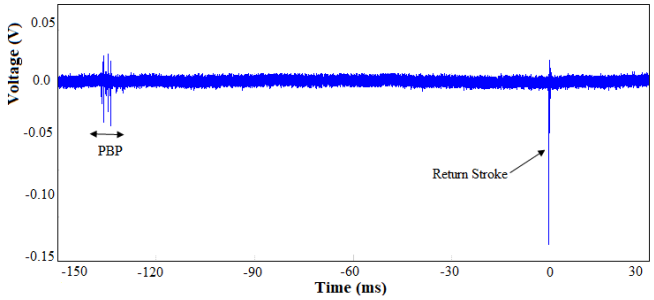

Figure 2: An example of positive cloud to ground flash recorded on 18 October 2018 at 4:18:23 PM

Table 1 shows the statistical information on +CG flash occurrence in Malaysia and Indonesia. [9], [10], and [11] recorded 21.91%, 2.10% and 33.14% +CG lightning respectively. [9] and [11] shows a significantly high +CG lightning percentage while [10] reported an acceptable value of +CG percentage. [12] discovered a numerous +CG data from a single storm with 102 event which is extraordinary abundance from a single storm. Next, [13] and [14] discovered a relatively low percentage of +CG lightning in Indonesia with only 0.68%. In this study, 4.44% positive lightning are detected from overall electric field data thus aligned with initial literature which stated that the occurrence of positive ground flashes is only about 10% compared to negative ground flashes.

Based on data reported by [9], [11] and [12] it can be noted that +CG lightning occurrence in this region are contradicted from the nominal value reported globally. Thus lead to uncertainty on the +CG lightning occurrences in this region.

Table 1: Statistics of positive cloud to ground flashes occurrences in di□erent studies in Malaysia and Indonesia

Investigator	Location	Measurement Period	Total Lighting Data	Positive CG Detected	Percentage (%)
Chan and Mohamed (2018) [9]	Pahang, Malaysia	Jan - Dec 2015	201,296	44,096	21.91
Wooi et.al (2015) [10]	Johor, Malaysia	Nov - Feb 2012	2289	48	2.10
Hamzah et.al (2015) [11]	Selangor, Malaysia	October 2013	172	57	33.14
Yusop et.al (2018) [12]	Melaka, Malaysia	14/09/2016	-	102	-
Hazmi et.al (2017) [13][14]	Padang, Indonesia	May - Oct 2014	11,392	77	0.68
This Study	Melaka, Malaysia	18/10/2018 18/11/2018	135	6	4.44

4. CONCLUSION

This paper presents an investigation of positive cloud to ground lightning flash from two thunderstorms in Melaka, Malaysia. The measurement has been done by using parallel plate antenna and connected to a 4-channel oscilloscope via an electronic buffer circuit. Six +CG flashes has been identified in this study with statistical percentage of 4.4%. A comparison study with other researcher in Malaysia and Indonesia has been done. From the study, it is noted that even though the research has been conducted at the same climatic region, there is uncertainty on the on the occurrence of +CG lighting. Therefore, this paper is a stepping stone to realize that the +CG has yet to be understood in this region. Thus, it is recommended for all researcher in this region to scrutinize positive lightning data with bulky data in a long period of time to ensure that the statistical information is accurate and the positive lighting electric field data is not misinterpreted.

REFERENCES

[1] M. A.Uman,***The lightning discharge***, vol. 39. International Geophysics Series Orlando, Academic, 1987.

[2] V. A. Rakov, **The Physics of Lightning**, *Surv. Geophys.*, vol. 34, no. 6, pp. 701–729, Nov. 2013.

[3] A. Nag and V. A. Rakov, **Positive lightning: An overview, new observations, and inferences**, *J. Geophys. Res. Atmos.*, vol. 117, no. 8, Apr. 2012.

[4] V. A. Rakov, **A review of positive and bipolar lightning discharges**, *Bull. Am. Meteorol. Soc.*, vol. 84, no. 6, pp. 767–776, 2003.

[5] D. Johari, V. Cooray, M. Rahman, P. Hettiarachchi, and M. M. Ismail,**Characteristics of leader pulses in positive ground flashes in Sweden,** *Electr. Power Syst. Res.*, vol. 153, pp. 3–9, 2017.

[6] V. A. Rakov and M. A. Uman, **Lightning: Physics and Effects**. New York: Cambridge Univ. Press, 2003

[7] Z. A. Baharudin, V. Cooray, M. Rahman, P. Hettiarachchi, and N. A. Ahmad, **On the characteristics of positive lightning ground flashes in Sweden**, *J. Atmos. Solar-Terrestrial Phys.*, vol. 138–139, pp. 106–111, 2016.

[8] N. A. B. Ramlee, N. Ahmad, M. R. M. Esa, Z. A. Malek, Z. A. Adzis, and Z. A. Nordeen, **Characteristics of Positive Lightning As Observed In Temperate and Tropic Regions: A Review**, in *2018 2nd International Conference on Electrical Engineering and Informatics (ICon EEI)*, 2018, no. October, pp. 159–164.

[9] H. G. Chan and A. I. Bin Mohamed, **Investigation on the occurrence of positive cloud to ground (+CG) lightning in UMP Pekan**, *J. Atmos. Solar-Terrestrial Phys.*, vol. 179, no. July 2017, pp. 206–213, Nov. 2018.

[10] C. Wooi, Z. Abdul-malek, B. Salimi, N. A. Ahmad, K. Mehranzamir, and S. Vahabi-mashak, **A Comparative Study on the Positive Lightning Return Stroke Electric Fields in Different Meteorological Conditions**, vol. 2015, 2015.

[11] M. N. Hamzah, M. Z. A. Ab Kadir, C. Gomes, and S. N. M. Arshad,**Unique Stroke-Multiplicity of Positive Lightning in Malaysia**, *Appl. Mech. Mater.*, vol. 793, pp. 39–43, 2015.

[12] N. Yusop *et al.*, **Cloud-to-Ground lightning observations over the Western Antarctic region**, *Polar Sci.*, no. May, pp. 0–1, 2019.

[13] A. Hazmi, P. Emeraldi, M. I. Hamid, N. Takagi, and D. Wang,**Characterization of Positive Cloud to Ground Flashes Observed in Indonesia**,2017.

[14] A. Hazmi, R. Desmiarti, P. Emeraldi, and M. I. Hamid, **Observed Electric Field Changes of Positive Lightning Flashes Preceded by Preliminary Breakdown in Padang**, vol. 9, no. 2, pp. 284–293, 2017.

[15] Z. A. Baharudin, M. Fernando, N. A. Ahmad, J. S. Mäkelä, M. Rahman, and V. Cooray,**Electric field changes generated by the preliminary breakdown for the negative cloud-to-ground lightning flashes in Malaysia and Sweden**,*J. Atmos. Solar-Terrestrial Phys.*, vol. 84–85, pp. 15–24, 2012.