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Misidentification of Type of Lightning Flashes in Malaysia

Puteri Nur Suhaila Ab Rahman*[1], Zikri Abadi Bharudin[2], Nur Hidayu Abdul Rahim[3]
Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka (UTeM),
Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia, Ph.: +606-5552267
*Corresponding author, e-mail: suellabp90@gmail.com[1], zikri@utem.edu.my[2], areyupeace@yahoo.com[3]

Abstract

The Lightning Detection System (LDS) system monitored by Malaysian Meteorological Service (MMS) and Tenaga Nasional Berhad (TNB) are not reliable that may due to unresolved site errors. From informal observation, Baharudin and co-workers found the data recorded by TNB was not identical to their data. In this paper, we observed about Lightning Flashes in Malaysia nearly 21 data matching the time and date of our data with data from TNB Reports that the lightning flash polarity between both data has a negative polarity, but there are differences on multiplicity. Regarding data from TNB Reports, they also noted that there was presented a total of 10 positive cloud-to-ground flash data, but we did not find any data positive cloud-to-ground flash data. However, the data we have found a total of 191 data were presented from cloud flash but TNB did not record any cloud flash.

Keywords*: lightning flashes, polarity, multiplicity, cloud-to-ground flashes*

1. Introduction

It is believed that downward negative lightning flashes account for about 90%. Typically, the tropical country such as in Malaysia was found to have only negative cloud-to-ground lightning flashes as reported by many investigators. Malaysian Meterological Service (MMS) has been responsible in collecting data on thunderstorm event (including lightning ground flash and cloud discharge) day level for more than 30 years. The lightning ground flash density Ng is defined as the number of cloud-to-ground flashes in km-2 yr-1, is actually an important meteorological data that is used in calculating the risk of lightning strikes to a structure, avionic system, flight activities and any sensitive devices. Furthermore Tenaga Nasional Berhad (TNB) also play role for monitoring this activity since 1995. It is believe that the MMS or TNB used the well-known type of lightning measurement for Lightning Locating system (LLS) such as magnetic direction finding (MDF), time of arrival (TOA) and interferometry. The arrangement can be either individual or combination of all types. In 2003, Hartono [1] reported about the availability of lightning data recorded by MMS or TNB. He claimed that the data collected either by MMS or TNB presented site error in their mapping system. They suggested that this error may due to unresolved site errors inherent in the existing Lightning Detection System (LDS). Moreover, Pinto and co-workers [2] also claimed the same issue as pointed by Hartono that the availability data of LDS in Malaysia are not reliable. In 2009, the work of Baharudin and co-workers has reported and characterized lightning activities ([3-5]) in Malaysia successfully. However, from their informal comparative study between their data and the data recorded by TNB were found to be not identical to each other. Moreover they found a positive ground flashes were registered in TNB system while in their measurement, that type of flashes never appeared in their system. The positive ground flashes is actually considered as a unique flashes that only occurred in temperate region (latitude above 30 degree). This issue really raised a big doubt on the reliability of LDS for MMS or TNB.

In principle, “negative cloud-to-ground lightning flash” or “negative ground flash” may consist of a single stroke or several strokes. Each stroke involves a combination of a downward leader and an upward return stroke, or better known as the leader-return-stroke sequence. Furthermore, these characteristics combined with the relationship between the season, location and storm type, are beginning to be of interest to researchers for the purpose of weather

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forecast, climatology and the designing of lightning protection systems. For example Darveniza and co-worker [7] showed that the failure modes of surge-protective devices deployed in power systems depend on the number of strokes per flash and interstroke intervals.

This study notes that the number of strokes per flash and the interstroke intervals are very important parameters to consider in co-ordinating the circuit breakers in power distribution systems. The characteristics of the negative cloud-to-ground lightning flashes, as reported by Rakov and Huffines [6], can be considered as a reliable benchmark in recognizing the “accurate-stroke-count” studies, which is based on two types of measurement techniques: (1) measurements based on the correlated electric field recording on the electric fields generated by the whole flash with high levels of temporal resolution (performed by Cooray and Perez (1994) in Sweden and Cooray, and Jayaratne (1994) in Sri Lanka); (2) a combination of (1) and high speed photographic records, as utilized by Kitagawa et al. (1962) in New Mexico, Rakov and Uman (1990), and Rakov et al. (1994) in Florida. Prior to this study, Cooray and Jayaratne (1994) compared their observations with the data set in Sweden by Cooray and Perez (1994) and in Florida by Thottappillil et al. (1994). They reported a remarkably good agreement with the characteristics of negative cloud-to-ground flash, such as the number of strokes count (mean, percentage of single-stroke flashes), amplitude distribution of the SRS, and the interstroke intervals. [6] emphasized that the percentage of “accurate-stroke-count” studies of single-stroke flashes (14 to 21%) in New Mexico, Florida, Sweden and Sri Lanka were fairly similar to each other. In addition, [6] explained about the difference between the “accurate-stroke-count” and the Lightning Locating System (LLS) studies such as the U.S. National Lightning Detection Network (NLDN) for Florida and New Mexico, and Austrian Lightning Detection and Information System (ALDIS) network. First, in many multiple-stroke ground flashes, only one stroke is recorded by the lightning detection networks which considered that many SRS failed to exceed the system’s trigger threshold level in NLDN and ALDIS networks. Furthermore, the percentage of peak current measured by using NLDN and ALDIS were found to be very low. The other consideration is that the first stroke is usually larger than SRS which is likely to be the first recorded stroke. Second, the stroke-grouping algorithm of the lightning detection network (NLDN) defines one stroke from a flash and assigns it to a separate flash. This is the case either when two strokes in a flash have longer interstroke intervals by more than 500 ms or when a stroke terminates on ground by more than 10 km from the first stroke of the flash. Third, some of the single-stroke flashes reported by NLDN and ALDIS were missed to be identified as cloud flashes. The lightning detection network systems assume that a cloud flash is unlikely to produce more than one pulse. Therefore, the pulse is accepted by the systems as a cloud-to-ground lightning RS pulse. Overall, [6] concluded that the percentage of single-stroke flashes reported by the NLDN is a factor of 2 to 3 times higher than the “accurate-stroke-count” studies in Florida and is a factor of 3 to 4 times higher in New Mexico.

In this paper we validate the data from TNB Research t identification data corresponding to almost 21 sample data were taken at the same time between our measurement and TNB Researcher. Based on the statement above regarding the multiplicity features, we reexamine our existing samples shows that there was no positive lightning from 2004 to 2007 in Peninsular Malasysia by denied the the data from TNB Research of Abdullah N [9]. TNB Researcher mentioned that they have detected the positive lightning in Peninsular Malaysia.

2. Research Method

2.1. Summary of TNB Research on Lightning Flashes details within 5km radius

Refer from lightning data analysis report of TNB Research of Table 1(a) or Table 1 below of summary of lightning flash details within 5km radius; was there were no detail explanation for the type of flashes either cloud flashes or ground flashes. There's only mentioned about polarity of the flashes either Positive (P) or Negative (N). While from Table 1(b) from lightning data analysis report of TNB Research of Lightning flashes details; the features of multiplicity which also known as number of stroke in ground flashes were mentioned. That means all the sample that given from the lightning data analysis of TNB Research were considered as ground flashes.

Table 1. TNB Research summary of lightning flash details within 5km radius

Type of Flash vs Return Stroke	Flashes (all polarity)	Flashes (N)	Flashes (P)
Number of flashes	94	84	10
Min first return stroke current (kA)	8.8245	8.8245	12.4135
Max first return stroke current (kA)	113.7195	113.7195	22.8845
Average first return stroke current (kA)	33.6277	35.6061	17.0089

2.2. Measuremet Use

The measurements of electric fields generated by negative ground flashes were recorded from April to June 2009 during the southwest monsoon period in the Johor state at the southern part of Peninsula Malaysia, in close proximity to the equator (Latitude:1°N, Longitude:103°E). Our measurement station altitude is 132m above sea level and approximately 30km away from Tebrau Straits.

We had used three parallel plate antennas to sense fast electric field, radiation field at 3 and 30MHz signals, while a whip antenna was used to sense the slow electric field signal. The antenna system for the fast and slow electric field electronic buffer circuits used for both measuring sites are identical to the literatures described in Cooray and Lundquist (1982), Galvan and Fernando (2000) and Cooray (2003). The whip antenna consists of a lower metallic rod, an upper metallic rod (3.3m) and an insulator. The lower metallic rod is buried about 0.5m in the ground while the other end is about 1.5m above the ground level.The upper and lower metallic rods were insulated from each other by using an insulator of 0.05m thickness which have the capacitances of 58pF. The physical height, insulator thickness and diameter of parallel flat plate antenna is 1.5, 0.05 and 0.45m, respectively. All three flat plate antenna were placed side by side with a distance of 1m from each other. The whip antenna was placed 3m away from the flat plate antenna system. They were located 8m from the control room where the recording system was set up. The plane of antenna is oriented parallel position to the ground, which to ensure the horizontal electric field effect can be eliminated.

A 60cm long coaxial cable (RG58) was used to connect the antenna to the electronic buffer circuit for slow and fast electric fields. The zero-to-peak rise time of the output was less than 30ns when the step input pulse is applied to the fast electric fields antenna system. The decay time constant for the fast and slow electric field circuit is determined by the RC circuit. We tune the decay time constant for the certainty fast and slow electric field circuit to the 15ms and 1s, respectively.The decay time constant for the fast electric field was found to be sufficient for faithful reproduction of micro-second scale while the value for the slow electric field was long enough to allow in our analysis. The tune circuit at 3MHz is a combination of passive elements where the inductance (47μH) is connected in series with the antenna (58pF) and 50Ω termination forming a simple RLC circuit. The tune circuit at 30MHz was constructed by using an active bandpass topology consists of LMH6559 (speed buffer) and LMH6609 (voltage feed back operational amplifier). The bandwidth of a tune circuit is at 3 and 30 MHz are 264 kHz and 2 MHz respectively.

Signals from all antenna were fed by 10m length coaxial cables (RG-58) into a 4-channel 12-bit digital transient recorder (Yokogawa SL1000 equipped with DAQ modules 720210) through proper termination (50Ω termination). The sampling rate was set to 20 or 100MS/s with the total length recorded being either 0.25 or 1s. The transient recorder was operated either in 125 or 300ms in pre-trigger mode. The trigger setting of the oscilloscope was set such that for the signals of both polarities could be captured.

The close distance of the negative ground flashes with a distance less than 16km were calculated using the thunder ranging method. In this method, the elapsed time between the arrivals of the electric pulses and acoustic signals is divided by the speed of the sound to arrive at the distance of the flash. There is an approximate 1s delay of a possible error when the first electric pulse is displayed in the scope. The trigger level is set in a range of 500mV- 2V, to ensure only close flash could be recorded. Although the thunders for the close flashes were audible for less than 20km, we only limit our selection to less than 16km to prevent from an uncertainty in time correspond to an uncertainty in distance.

The characteristic of the fast electric field waveform is crucial since it has good reliability to indicate a clear selection of processes preceding the first negative return- stroke. In addition, the slow electric field waveform is compulsory to identify the starting position of electric field changes correctly that precede the first negative return stroke. Furthermore, the use of narrowband system (HF radiation at 3MHz) feature allows decreasing uncertainty especially detect to the first preliminary breakdown pulse.

2.3. Cloud Flashes vs Cloud-to-ground Flashes

The differences between Cloud Flash and Cloud-to-ground Flash characteristics.

2.3.1. Cloud Flash

If the discharges happen inside a thundercloud or between thunderclouds, the terms intracloud flashes or cloud flashes (ICs) are typically used as shown in Figure 1. Cloud discharge is the most common of all types of lightnings [10]. ICs usually occurs between the center and the center of positive charge on the lower negative charge.Complete discharges has the order of 0.2 seconds during which time a continuous luminosity observed in the cloud. It is thought that during these periods the leaders spread narrowing the gap between the two centers responsible. Overlap in continuous flashes some quite bright light pulses that time period about 1msec. It would appear from the measurements of the electric field that pulses of light is relatively weak return stroke that occurs when passing acquaintance pockets leader is responsible for the polar opposite of a leader.The amount charged may be released intracloud neutralized in the same order of magnitude as the subject land is transferred in the cloud to be released. IC lightning still in the clouds and is the most common type of discharge [11].

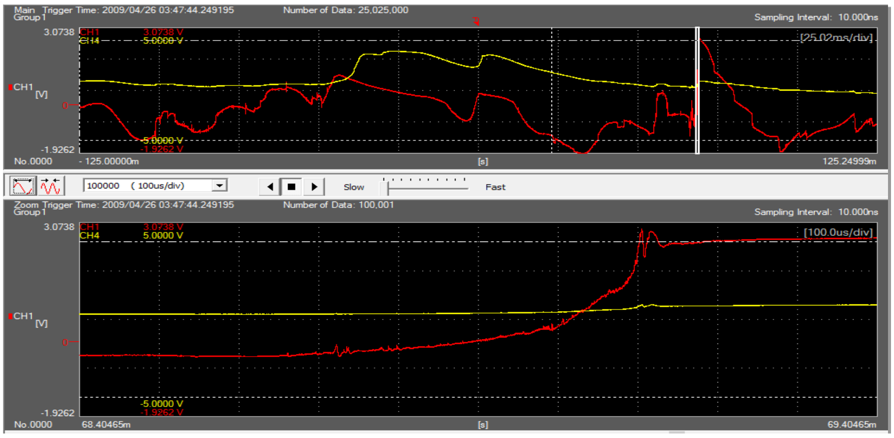

Figure 1. Cloud Flash

2.3.2. Cloud-to-Ground Flash

Approximately one third of the lightning discharge travels between charges in the cloud and the ground. We will use the term cloud-to-ground as shown in Figure 2 through as we shall see some quite rare flash emission from the ground and travel up towards the release cloud. Most cloud-to-ground (CG) with carry a negative charge to the ground.Most began with the release of the CG cloud, preliminary breakdown process. Also one of the lower positive charges may be invoved in the negative CG discharge. Some CG release was higher in the clouds and carries a positive charge to the ground. Positive CG discharge is more common at the severe thunderstorms where the vertical wind shear is present. Usually the center of positive charge on the primary negative charge and discharge between the two ewmain in the cloud. Wind shar can cause clouds to leaning and move some of the positive charge away from the correct positon in the center of negative charge. Relief can travel from cloud to ground. Positive CG discharge also more common on the storm at high lalituteds where the central positive charge is closer to the ground. Then, this positive CG discharge also common in the winter storms with the central positive charge was closer to the ground. Also, the positive CG discharge common at the end of summer storms where the cloud may tilt and the mean number of positive charge can be found on the anvil cloud and away from the main body of the cloud. The sequence of process that occur during the negative cloud-to-ground begins with some type of early release of the cloud. Then, down the release of negatively-chared move started moving towards ground. Negative charge is carried from the center of neagtive charge along the channel and distribited leader [11].

Return stroke propagates from ground to cloud. When the stepped leader has lowered the negatively charged column of high incoming to near the ground, the quality of the resulting electric field at the ground is sufficient to cause upward-moving discharged to be launched from ground towards the leader tip. When one of these contacts discharges the leader is connected to ground potential effectivly, while the remainder of the leader is at negative incoming and it is negatively charged [11]. The positive electric field changes at ground level is defined in terms of the displacement of negative charges downward and positive charges being raised upward similar to the electric field change of negative return strokes.

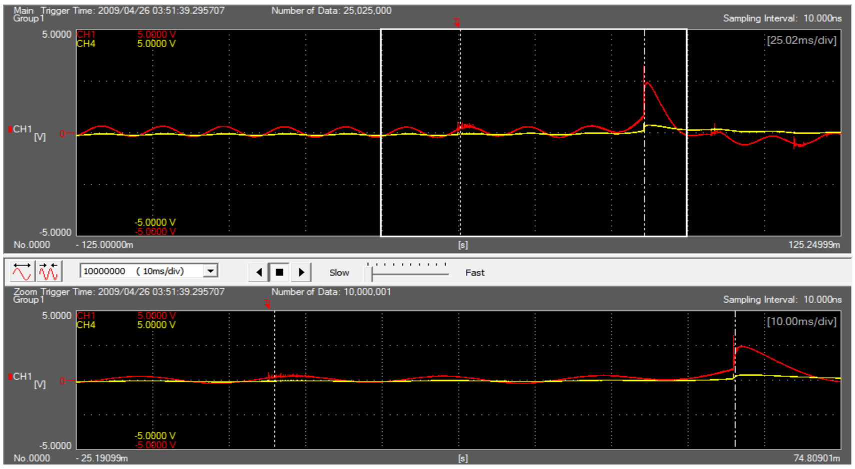

Figure 2. Cloud-to-ground Flash

3. Results and Analysis

3.1. The Differences of Record Time, Polarity and Multiplicity from our Result with TNB

Table 2. The Differences of Record Time, Polarity and Multiplicity from our Result with TNB

Record Time (us)	Record Time (TNB)	Polarity (us)	Polarity (TNB)	Multiplicity (us)	Multiplicity (TNB)
2009.04.11; 18:35:18.406	2009.04.11; 18:35:57.026	N	N	5(-ve CG)	1
2009.04.13; 16:40:46.459	2009.04.13; 16:40:36.348	N	N	3(-ve CG)	1
2009.04.14; 18:08:37.698	2009.04.14; 18:08:36.296	N	N	1(-ve CG)	1
2009.04.14; 18:11:31.682	2009.04.14; 18:11:30.647	N	N	1(-ve CG)	1
2009.04.14; 18:14:18.445	2009.04.14; 18:14:07.619	N	N	3(-ve CG)	1
2009.04.14; 18:14:44.896	2009.04.14;18:14:55.546	N	N	2(-ve CG)	1
2009.04.14; 18:16:35.229	2009.04.14; 18:16:49.602	N	N	0	1
2009.04.14; 18:18:46.232	2009.04.14; 18:18:36.646	N	N	2(-ve CG)	1
2009.04.14; 18:19:47.035	2009.04.14; 18:19:53.615	N	N	3(-ve CG)	1
2009.04.26; 11:34:27.015	2009.04.26; 11:34:18.623	N	N	Cloud Flash	1
2009.04.26; 11:36:54.857	2009.04.26; 11:36:46.062	N	N	Cloud Flash	3
2009.04.26; 11:36:54.857	2009.04.26; 11:36:58.858	N	N	Cloud Flash	2
2009.04.26; 11:40:12.777	2009.04.26; 11:40:26.834	N	N	Cloud Flash	1
2009.04.26; 11:41:23.534	2009.04.26; 11:41:37.234	N	N	2(-ve CG)	2
2009.04.26; 11:43:02.452	2009.04.26; 11:43:16.187	N	N	4(-ve CG)	3
2009.04.26; 11:47:44.249	2009.04.26; 11:47:47.259	N	N	Cloud Flash	2
2009.04.26; 11:48:26.260	2009.04.26; 11:48:22.479	N	N	3(-ve CG)	1
2009.04.26; 11:49:26.367	2009.04.26; 11:49:05.279	N	N	Cloud Flash	2
2009.04.26; 11:51:39.295	2009.04.26; 11:51:55.576	N	N	1(-ve CG)	1
2009.04.26; 11:53:15.867	2009.04.26; 11:53:04.414	N	N	2(-ve CG)	2
2009.04.26; 11:55:48.012	2009.04.26; 11:55:45.402	N	N	2(-ve CG)	2

From Table 2 the differences of Time Record, Polarity and Multiplicity from our result with TNB have shown that nearly 21 data matching time and date.This suggest that the polarity of lightning flash between both data have the same polarity which are negative polarity. But there are widely different due to the multiplicity of both data. Multiplicity refers to the number of returns stroke due to lightning ground flash. From our data, there not only have cloud-to-ground flashes only, but it shows that data we have detected the present of cloud flash in the same day. Our data can be recorded that there were 6 of 21 data cloud flash and 15 of 21 data are cloud-to-ground lightning flashes while recording TNB data is only from cloud-to-ground lightning. Only 5 data that have same multiplicity between our data and TNB.

On 11th of April 2009, out of 136 of our data only 1 data has been matched record time with TNB; TNB only recorded 3 data. TNB and data we have recorded the same flash and polarity which of cloud-to-ground flash with negative polarity but with different numbers of multiplicity. TNB are only having a number of returns stroke but our data having five number of return stroke due to ground flash.

On 13th of April 2009, of the 151 data we recorded, only 1 data has matched the data recorded by TNB; TNB only recorded 4 data. TNB and our data had shown the same flash and polarity of cloud-to-ground flash with negative polarity but different number of multiplicity. The data we have recorded have three number of return stroke due to lightning ground flash, but there is only one number the TNB multiplicity.

On 14th of April 2009, from 59 to our data, only 7 data were matched record time with TNB; TNB only recorded 18 data. From 7 data matched, only 2 data from TNB and our data was recorded the same lightning flashes, polarity and several variations of cloud-to-ground lightning of negative polarity with a number of return stroke due to ground flash as a result. Another 5 data from these 7 data recorded math was recorded the same cloud-to-ground flash with negative polarity but different on number of multiplicity. From 5 data recorded, it indicates that the data we have of 3 types of several variations present either zero with no number of return stroke which is initial return stroke ruins or on preliminary breakdown state, a number of return stroke with 2 data and two number of return stroke with 2 data present but the data that TNB posted there only one kind of multiplicity that is one of several return stroke as a result of this ground lightning.

On 26th of April 2009, 159 of our data, only 12 have been matched data recorded with TNB; TNB only recorded 20 data. Of these 12 matched data, only 4 have the same polarity data, the types of lightning flash and number of multiplicity which are negative polarity of cloud-to-ground flash and either the number of multiplicity is one or two. Out of this 12 data matched, only 6 have the same data on negative polarity but differe in the type of flash. From the data we recorded 6 is found that cloud flash is present but TNB recorded data from cloud-to-ground flash with different number of multiplicity either one, two or three of lightning return stroke from ground. The rest of the data from 26th of April 2009, which is 2 data have the recorded the same types of polarity but different on number of multiplicity. 1 data out of this 2 data recorded that TNB has found three number of return stroke but we found the four number of return stroke due to ground flash. Another 1 data recorded, TNB has been found that there is only one number of returns due to lightning ground flash but the data we have found of three number of return stroke due to ground flash.

3.2. The Differences between our Data with TNB Based on Total Flashes, Cloud Flash, Negative and Positive Cloud-to-ground Flashes

Table 3. The Differences between our Data with TNB Based on Total Flashes, Cloud Flash, Negative and Positive Cloud-to-ground Flashes

Differences	Date	Flashes (all polarity)	Cloud-to-ground Flashes (negative)	Cloud-to-ground Flashes (positive)	Cloud Flash
TNB Report	1st - 26th April 2009 (except 20th - 25th)	94	84	10	0
Us	11th- 26^{h} April 2009	1130	939	0	191

Based on Table 3 it shows the difference between our data with TNB based on the number of total Flashes, Cloud Flash, negative and positive Cloud-to-ground Flashes. The TNB Report were recorded the data from 1st of April until 26th of April 2009 except 20th of April until 25th of April 2009 as scheduled central processor upgrading work.

Our data were recorded from 11th of April until 26th of April 2009. TNB has analyzed the total number of flashes that they recorded only from one type of flash which is cloud-to-ground flash with both polarity of positive and negative with a total of 94 data flash. Although the data we have analyzed that the flashes that we recorded come from two types of flashes which are cloud-to-ground flashes and cloud flash with total 1130 data flashes. TNB data posted there are only 84 data based on negative cloud-to-ground flashes, but data we recorded 939 data.Regarding to data from TNB Reports, they also noted that there was presented a total of 10 positive cloud-to-ground flash data, but we did not find any positive cloud-to-ground flash data. However, the data we have found there are a total of 191 data were presented from cloud flash but TNB did not record any cloud flash.

3.3. A Qualitative Comparison between others Researcher on Present of Thunderstorm, Negative Ground Flash, Positive ground Flash and Cloud Flash

From Table 4 based on the a qualitative comparison with the certain duration of time on the thunderstorm exist and types of flashes between Baharudin, Z. A. 2012 (a) [3], Baharudin, Z. A. 2012 (b) [4], N. Azlinda 2009 (a) [5], N. Azlinda 2009 (b) [8], Abidin, H. Z. [1], Abdullah, N. [9], TNB Research Report and Abdullah, N [12].

Table 4. A Qualitative Comparison between Researcher.

Study	Duration Time	Thunderstorm	Negative Ground Flash	Positive Ground Flash	Cloud Flash
Baharudin, Z.A. 2012 (a)[3]	April - June 2009	21	1299	0	533
Baharudin, Z.A. 2012 (b) [4]	April - June 2009	-	24	0	-
N.Azlinda, 2009 (a) [5]	April - June 2009	-	-	0	182
N.Azlinda, 2009 (b) [8]	April - June 2009	-	900	0	140
Abidin, H.Z. [1]	1993-2002	3779	-	0	-
TNB Research Report	April - May 2009	-	84	10	0
Abdullah, N. [9]	2004-2007	-	7 015 030	1 712 368	-
Abdullah, N [12]	2008-2011	-	3 053 795	611 491	0

From Baharudin, Z. A. 2012 (a) [3], it shows that the there have existing 21 thunderstorms data with present of 1299 of negative ground flash and 533 of cloud flash of duration time April to June of 2009. Then, data Baharudin, Z. A. 2012 (b) [4] of duration time April to June of 2009, it only mentioned existing of 24 data of negative ground flash. From April to June of 2009 of data N.Azlinda 2009 (a) [5] presented 182 of cloud flash while from data N. Azlinda 2009 (b) [8] mentioned the presented of 900 of negative ground flash and 140 cloud flash. Data of Abidin, H. Z. [1] on duration of time from year of 1993 until 2002 there only mentioned of existing 3779 thunderstorm without noticed any type flashes present. TNB Research Report from April to May 2009 have mentioned that there have 84 data of negative cloud flash and 10 data of positive cloud flash. From year 2004 to 2007 of Abdullah, N. [9] data there presented 7 015 030 of negative cloud flash and 1 712 368 of positive cloud flash. From year 2008 until 2011 Abdullah, N. [12] recorded data with existing 611 491 of positive ground flash and 3 053 795 of negative ground flash.All the data were measured in Malaysia. A qualitative comparison of our results with those obtained from Baharudin, Z. A. 2012 (a) [4], Baharudin, Z. A. 2012 (b) [3], N. Azlinda 2009 (a) [8], N. Azlinda 2009 (b) [5], and Abidin, H. Z. [1] supports the hypothesis that the positive lightning does not exist in Malaysia. While data from Abdullah, N. [9], TNB Research Report and Abdullah, N [12] reported there exist positive cloud-to-ground flash in Malaysia.

4. Conclusion

We have analyzed that there are no positive lightning flashes in Malaysia but our the data have found there are existing cloud flash and negative lightning falshes only as supported by Baharudin, Z. A. 2012 (a) [4], Baharudin, Z. A. 2012 (b) [3], N. Azlinda 2009 (a) [8], N. Azlinda 2009 (b) [5], and Abidin, H. Z. [1].

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