CHARACTERISTICS OF POSITIVE CLOUD TO GROUND FLASHES IN MALAYSIA AND CORRELATION WITH CLOUD TOP HEIGHT

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To my beloved parents, sister,
mighty supervisor, lecturers, friends and to those helped me to complete this project successfully

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ABSTRACT

Positive cloud to ground (CG) flashes lowers positive charges from cloud to ground. Positive CG grasps more attention since they are highly allied with severe thunderstorms. Positive CG is known to account only approximately 10% out of all CG flashes. The positive CG can be compared with negative CG, IC (intra cloud) and NBE (narrow bipolar event) flashes. The experimental setup to capture the electric field produced by the lightning flashes has taken place at UTeM Melaka. The measurement setup consists of 2 parallel plates, buffer circuit, antenna, high speed camera, GPS, Picoscope digitizer, and computer. The NBE, preliminary breakdown pulses, and first return stroke are included in this process. From the recorded data, very few positive CG have been captured. This is because the occurrence of positive CG is very less in low latitude countries due to the absence or very less anvil shape of the clouds. It is found that the occurrence of positive CG is very less about which is approximately 1.275% by average in two days and the cloud top height is about 13km to 14 km during the occurrence of positive CG.

ABSTRAK

Kilat jenis *positive cloud to ground (+CG)* berlaku disebabkan oleh caj positif dibawa turun dari awan ke tanah. +CG harus diberikan lebih perhatian kerana ia memberi kemungkinan besar kepada kejadian hujan yang disertai guruh dan kilat yang sangat kuat dengan kekerapan yang tinggi. Dianggarkan hanya 10% dari jumlah kilat yang direkodkan adalah +CG dan ia boleh dibandingkan dengan jenis-jenis kilat yang lain seperti *negative CG, intracloud (IC)* dan *Narrow Bipolar Event (NBE).* Sistem pengukuran kilat yang telah dipasang di Universiti Teknikal Malaysia Melaka (UTeM) terdiri daripada 2 antena plat selari, litar pengikut (*buffer*), kamera kelajuan tinggi, GPS, Pendigit Picoscope, komputer peribadi dan unit storan luaran. Sebanyak 4000 data yang dikumpulkan pada 29hb dan 30hb Mac 2017 dan telah dianalisis. Semua data yang dipilih untuk dianalisis adalah terdiri daripada kejadian kilat iaitu NBE, seluruh proses +CG bermula dari *Preliminary Breakdown Process* (PBP) sehingga *Return Strok*e pertama. Dari senarai data yang telah direkodkan, didapati hanya kira-kira 1.275% dari 4000 data adalah +CG dan kebanyakan berada di paras ketinggian awan antara 13 km hingga 14 km. Kekurangan kejadian +CG di Malaysia adalah disebabkan kedudukan Malaysia di kawasan berlatitud rendah. Pembentukan awan berbentuk andas atau landasan (*Anvil Cloud*) yang jarang juga penyebab kepada kurangnya +CG direkodkan di Malaysia.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CAPPI	-	constant altitude plan position indicator
CG	-	cloud to ground
CID	-	compact intracloud
IC	-	intracloud
IEEE	-	Institute of Electrical and Electronics Engineers
IRIS	-	Interactive Radar Information System
MDF	-	magnetic directional finding
NBE	-	narrow bipolar event
NBP	-	narrow bipolar pulse
NNBE	-	narrow negative bipolar event
NNBP	-	narrow negative bipolar pulse

NPBP	-	narrow positive bipolar pulse
PBP	-	preliminary breakdown pulse
RC	-	resistor capacitor circuit
RS	-	return stroke
Vs	-	versus
UTeM	-	Universiti Teknikal Malaysia Melaka

LIST OF SYMBOLS

+	-	positive
—	-	negative
^{o}C	-	degree Celsius
Q	-	charge
C	-	Coulomb
ms	-	millisecond
A	-	ampere
kA	-	kiloampere
km	-	kilometer
µs	-	microsecond
%	-	percent
ms^{-1}	-	meter per second

^{o}N	-	degree North
^{o}E	-	degree East
Hz	-	Hertz
kHz	-	kilo Hertz
1st	-	first
dBz	-	decibel relative to reflectivity factor
hPa	-	hectoPascal
V	-	Volt
mV	-	milli Volt
nF	-	nanofarad
pF	-	picofarad

CHAPTER 1

INTRODUCTION

1.1 Background of Study

When a huge electrical discharge occurs in the atmosphere of the Earth, a lightning is produced which have a total length of tens kilometers or more. Thunderclouds produce most of the lightning and it is said more than half of the discharges would remain inside the clouds. In common, most of the cloud to ground (CG) flashes lower the negative charges to ground but there also events whereby positive charges are also being lowered to ground which is known as positive cloud to ground flashes [1]. All types of CGs can easily kill people and would cause millions of dollars when it comes to property damages. The lightning activity follows a specific pattern with the intracloud (IC) lightning, specifically appearing in the developing stage followed by CG during the mature stage and on the other hand both types of lightning also can happen in the stage of decay of thunderstorms [2]. Because of the simplicity to study, the CG discharge remains the most remarkable despite the significant interest in the IC and other several transient optical phenomena in the atmosphere [3].

At the beginning of a lightning, most CG starts within the cloud whereby there are huge concentrations of positive and negative space charges. Then, preliminary cloud breakdown triggers an intermittent, discharge that has branches that propagates in all directions which is known as stepped leader. Once the stepped leader's tip gets close to the surface of the ground, the large electric field is produced near the surface which can cause one or more upward propagating discharges to develop. On the other hand, first return stroke is developed when an upward moving discharge makes contact with the stepped leader, it is wave of ionization which is intense which begins just above the ground that moves up the leader channel which is about one third of the speed of light [1].

A normal value of the peak current is almost 40,000 amperes and the peak electric power that is dissolute by a return stroke is about 100 million watts per meter [1]. The speedy expansion of the hot and high-pressure channel can produce shock waves and this may result in thunder with its characteristics. The ground potential will be carried by the currents in the return stroke which will neutralize most of the channels of the leader. Approximately after 40 to 80 milliseconds, the CG flashes produce a new leader which is the dart leader whereby it propagates down the previous return stroke channel and starts a subsequent return stroke. Most of the flashes has 2 to 4 return strokes with each upsetting a variety volume of cloud charges.

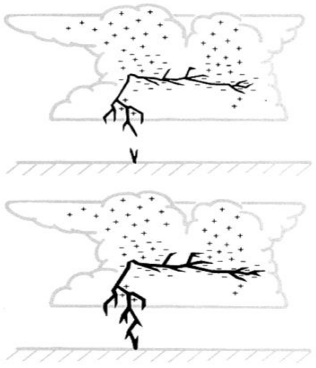

Figure 1.1 Stepped leader channel before attachment

The probability of lightning to strike to ground in more than one spot if the dart leader chooses a different path to ground than the earlier stroke. In the recent year of study, some discoveries have been made which is both the in cloud and CG flashes can generate very fast rising currents. Some non-equilibrium gas traces are generated within the high temperature channels of the lightning and by also the shock waves that can affect tropospheric and stratospheric chemistry [1].

One of the important parameters that need to be considered is the number of lightning strikes per unit time per unit area or is known as flash density [4]. The chemical properties of the lightning can play a vital role in the prebiotic synthetization of amino acids, besides that lightning is also still a source of fixed nitrogen, a natural fertilizer. Besides its many deleterious effects, lightning also has some unique benefits. Throughout the whole world, the dynamics of the ecosystems of forest has been dominated by the lightning fired fires. The radiation of the electromagnetic fields can be utilized to study the physics of propagation of radio and also long used in the study of geophysical.

To maintain the electric charge on earth, lightning charges can be very helpful. Some techniques have been identified to measure the properties of lightning which are acoustic, optical and electromagnetic sensors to estimate the characteristics of different discharges procedures on time scales ranging from tens of nanoseconds to some seconds. Early flashes documentation which lowers the positive charges from cloud to ground has been found in Berger's classical research (1967) which took place at Mount San Salvatore above Lake Lugano in Switzerland [1]. The measurements that must be taken into considerations are the electrostatic field change for the whole flash, fast electric and magnetic field wave forms for the return stroke.

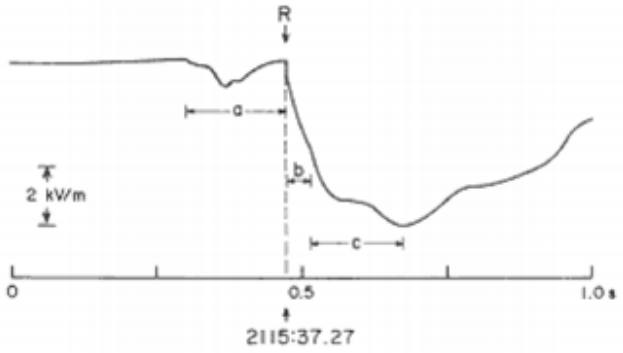

Figure 1.2 Electric field change for positive CG

1.2 Problem Statement

In general, positive lightning positive to ground flashes lowers positive charge from the cloud to ground whereby it happens very rarely [2]. It is only accounted about 10% of all the charges are positive CG [2]. Hence, the occurrences of positive CG in Malaysia are very rare compared to the positive Narrow Bipolar Events (+NBE) and negative CG. Many reviews and studies have been done on NBE and negative CG. Since positive CG is very rare, the characteristics of it have not been fully studied and discovered. When considering the tripole structure, the scarcity of the positive CG flashes can be easily accepted. Nevertheless, inside a cloud, the structure of it is still remain unresolved.

The research whether the climate in Malaysia has a significant production of positive CG will be studied and analyzed. The other types of CGs namely negative CG, positive NBE, intracloud charges have been studied and compared with positive CG to see and investigate the differences in them. In this research, the evolution of thunderstorm cloud top height which is obtained from the radar data has been analysed to correlate the

cloud top height with positive CG occurrences. Besides that, the research on the influence of positive CG to the thunderstorm in Malaysia has been done as well.

1.3 Objectives

The objectives that should be achieved throughout this project are:

i. To study the rainfall and thunderstorm rate in Malaysia correlate with the positive CG occurrences

ii. To investigate the correlation between positive CG with the cloud top height and study the possibility of it to contribute to the evolution of thunderstorms

1.4 Scope of Study

This study is focused on the:

i. Comparison between positive CG and other type of flashes

ii. Analysis of the correlation between positive CG and cloud top height

1.5 Thesis Outline

This thesis comprises of five main chapters which are introduction, literature review, research methodology, results and discussion and conclusion. Firstly, for the introduction part, it consists of background of study, problem statement, objectives, scope of study and thesis outline. Basically, for chapter one, it is more to the starter and overview of this project.

On the other hand, for Chapter two is the literature review part. In this chapter, upon studying and analyzing many journals from the trusted and reliable website like IEEE, summarization or abstract of the journals of renown authors have been done. Precisely, the formation of thunderstorm, cloud electrification, types of flashes which are positive CG, negative CG, intracloud and NBP, continuing current intensity in positive CG, characteristics of leader pulses in positive CG, positive return stroke and luminosity of return stroke are discussed in detail in this chapter.

For the third chapter, it is the research methodology part whereby the experimental setup, how measurements and data are taken are discussed here. Here, the flow chart of research work, introduction of certain software like IRIS software, Picoscope software, CAPPI and RADAR Data are also being deliberated here.

Fourthly, results and discussion part whereby the results of the project is revealed here. Sample of positive CG waveforms, positive CG correlated with Radar and CAPPI Data, cloud top height versus number of flashes on 29th and 30th March 2017 are written in the thesis. Furthermore, comparison of other flashes with positive CG is also included.

Lastly, is the conclusion and recommendation part whereby the findings of the project are discussed with suitable recommendations.

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