INVESTIGATION OF LIGHTNING DISTRIBUTION USING LIS DATA FROM TRMM SATELLITE

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Special dedicated to my beloved father, Zainal Yusof and mother, Rogayah Alias and also to dearest lecturer and friends.

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ABSTRACT

TRMM is a research satellite designed to monitor and study tropical rainfall and the associated release of energy that helps to power the global atmospheric circulation shaping both weather and climate around the world. Several methods have been used to improve understanding of climate space ground control center as the interaction between humidity, clouds and precipitation. Lightning Imaging Sensor (LIS) is one of TRMM satellite instruments which comprises of a staring imager optimized to locate and detect lightning with storm-scale resolution from 4 to 7 miles over a large area (600 x 600 km) from the earth's surface. This study present analysis on lightning features in Mid Latitude Region. In this study, we are investigating of lightning distribution from flash by measuring timely in Washington DC (38.54°N, 77.2°W) during January –April 2011 which useful to learn flashes passes through TRMM Satellite. A total 3,502,158 flash found during four month observation in this study. The highest number of flash occurs in April 2011 is 3,358,521 flashes compared to January 2011 showing the lowest flash about 3,993 flashes. This is because climate and atmosphere change that happened in Washington DC. During seasonal observation show that the spring season during March and April has highest creation of lightning compared to winter season in January and February.

ABSTRAK

TRMM ialah satu satelit penyelidikan yang memantau dan mengkaji hujan tropika dengan pembebasan tenaga yang membantu untuk mengkaji edaran global atmosfera dan iklim di seluruh dunia. Beberapa kaedah telah digunakan untuk meningkatkan kawalan ruangan bumi untuk memahami pusat cuaca antara kelembapan, awan dan pemendakan. Pengesan pengimejan kilat ialah bahagian instrumen satelit TRMM di mana ia terdiri daripada satu imej renungan yang mengoptimumkan untuk mengesan kilat dengan resolusi skala ribut (4 hingga 7 batu) lebih daripada satu kawasan yang luas (600 x 600 km) dari permukaan bumi. Analisis ini mengkaji kehadiran kilat yang terdapat di Mid Latitud dimana sunber lokasi dan masa kejadian dapat ditentukan melalui pancaran kilat. Lokasi di Washington DC (38.54° N, 77.2° S) yang dikaji selama empat bulan untuk memerhatikan pancaran aktiviti kilat melalui TRMM Satelit. Sebanyak 3,502,158 pancaran kilat ditemui pada empat bulan pemerhatian. Pancaran tertinggi berlaku pada bulan April 2011 sebanyak 3,358,521 pancaran berbanding pada bulan Januari 2011 yang menunjukkan taburan terendah pancaran kilat berlaku iaitu 3,993 pancaran. Ini disebabkan oleh perubahan iklim dan atmosfera yang berlaku di Washington DC. Pemerhatian dan analisis menunjukkan bahawa musim bunga pada bulan Mac dan April mempunyai taburan yang tertinggi berbanding musim sejuk pada bulan Januari dan Februari.

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TRMM	-	Tropical Rainfall Measuring Mission
JAXA	-	Japan Aerospace Exploration Agency
LIS	-	Lightning Imaging Sensor
VLF	-	Very Low Frequency
ELF	-	Extremely Low Frequency
KM	-	Kilometer
M	-	Mode
OTD	-	Optical Transient Detector
CG	-	Cloud-to-Ground
IC	-	Intra Cloud
Hz	-	Hertz
GHCC	-	Global Hydrology and Climate Center
GHRC	-	Global Hydrology Resources Center
TMI	-	TRMM Microwave Imager
VIRS	-	Visible Infrared Scanner
PR	-	Precipitation Radar
SSM/I	-	Special Sensor Microwave/Imager

CHAPTER I

INTRODUCTION

1.1 BACKGROUND

The Tropical Rainfall Measuring Mission (TRMM) is a joint mission between NASA and the Japan Aerospace Exploration Agency (JAXA) designed to monitor and study tropical rainfall [1]. It has five instruments on the TRMM platform include the TRMM Microwave radiometer (TMI), the Visible and Infrared Scanner (VIRS), the Precipitation Radar (PR) and the Cloud and Earth Radiant Energy System (CERES). Several methods have been used to improve understanding of climate space ground control center as the interaction between humidity, clouds and precipitation.

Lightning measured provided by the Lightning Images Sensor (LIS) on the Tropical Rainfall Measuring Mission (TRMM) offer a unique opportunity to develop combined data algorithms to investigate the electrical, microphysical and kinematic properties of tropical thunderstorm [2]. On November 28, 1997 [2], the LIS was launched into a low Earth orbit and now circles the Earth at an altitude of 350 km.

The inclination of this orbit is 35 degree, thus, allowing LIS to observed lightning of the globe as shown in Figure 1.1.

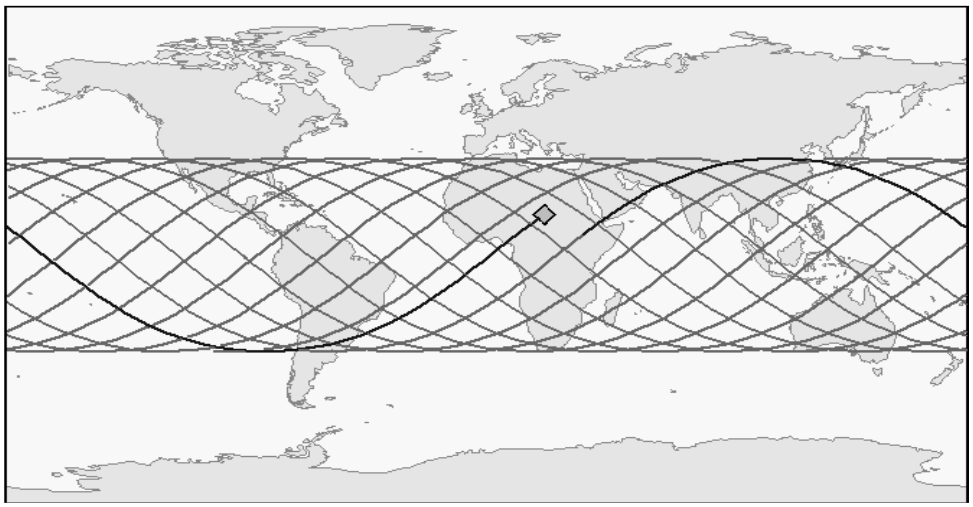

Figure 1.1: The LIS field-of-view and The Total Orbital Track of the TRMM Satellite during a 24 Hours Period

Source: [2]

This instrument will comprises of a staring imager optimized to locate and detect lightning with storm-scale resolution (4 to 7 miles) over a large area (600 x 600 km) from the earth's surface. It can detect the lightning in cloud-to-ground, intracloud and cloud-to-cloud. This is intended to record the time of the incident, measuring radiant energy, and determine the location of lightning events.

In this project, the lightning activity will be investigated during January to April 2011 at Washington DC (38.54° N, 77.2° S). The LIS data will be used to investigate the distribution of lightning in term of the weather aspect, time and distance. Every data taken will be analyze and compare with existing data getting from different other source of measurement. This is important to study the distribution of lightning from flash in mid latitude region by using different kind of measurement

1.2 PROBLEM STATEMENT

The properties of signal that are produced during the lightning have been investigated and explained by many number of researchers [9, 13, 14]. A variety of resources and technologies can be used to obtain the required information and data from lightning activity. Previously the data obtained from different source which is VLF receivers showed the highest percentage found in equinox seasons than winter. Thus, each analysis made will have different views and arguments by researchers. Therefore, this project has been come out to validate and study by comparing the existing data between the different data source.

1.3 SIGNIFICANCE OF PROJECT

This project could give opportunity to student to study phenomenon which occurred on earth. Phenomenon lightning often occurs at earth during rainy season until can cause damage in environment and can be fatal. Lightning happened when air fluctuate in cloud cause separatist positive charge and negative. Lightning is discharge resultant when difference electric charge between earth surface and atmosphere that big enough to overcome air insulation effect. Various studies completed and much information was gathered from lightning. This information will be used to detect and give warning thunderstorm, monitor formation tornado, estimate rain and others. This study also help student to learn lightning features which occurred in atmosphere.

1.4 OBJECTIVES OF PROJECT

Observation, understanding and effectiveness of the global climate can be obtained through the Tropical Rainfall Measuring Mission (TRMM). Lightning Images Sensor (LIS) will contribute significantly to the number of TRMM mission objectives by providing global lightning and thunderstorms climate change (even subtle temperature variations) may be easily detected. The objectives of this project are:-

i. To validate the distribution of lightning at Mid-Latitude Region.
ii. To analyze the distribution between different source of lightning data.
iii. To compare the distribution of lightning using LIS data and others source of data.

1.5 SCOPE OF PROJECT

The main scope of this project is to investigation of lightning distribution using LIS data in Washington DC. This project requires an effort to analyze the data distribution of lightning using the Lightning Imaging Sensor (LIS) which is one of TRMM Satellite Instrument. The study involved the distribution of lightning activity found in Washington DC (38.54°N, 77.2°S). The analysis is based on four months observation in January to April 2011. The result is categorized to monthly basis (January – April 2011), daily summaries (1st 2011 – 31st 2011) and hour summaries (00-00 UTC - 23:00 UTC).

1.6 CHAPTER ORGANIZATION

This report consists of five chapters. All the summary of each chapter are describe as following.

- Chapter 1: This chapter is included about the problem statement, objectives of project, scope of project, significant of project and chapter organization.
- Chapter 2: This chapter will discuss more on theory and literature review about the characteristics and formula that used in this project. This chapter also contain the previous researches that have been collected from different source for analyze of the project.
- Chapter 3: This chapter is about methodology of the project. It will explain the method and parameter in detail such as the software to collect data using Lightning Imaging Sensor (LIS).
- Chapter 4: This chapter is about the result and discussion of this project. It will show the student observation in this project.
- Chapter 5: This chapter will discuss the conclusions and recommendation for the further research when the others student want to analysis or compare the data using different source in the future.

CHAPTER II

LITERATURE REVIEW

2.1 INTRODUCTION

A few literature reviews have been completed in a number of sources to complement this project. Theory and analysis that ever committed by analysts previously have been taken as guidance in complement this project. In this chapter, an overview analysis that was explained with existing data. Every analysis that produced to have explanation that careful that could be taken as reference.

2.2 TROPICAL RAINFALL MEASURING MISSION (TRMM) BACKGROUND

The idea behind the development of Tropical Rainfall Measuring Mission (TRMM) had been generated in the early 1980's [3]. Despite its importance towards global weather and wind circulation, the tropical rainfall is still very uncertain especially over vast ocean. Thus a measurement from space using a combined instrument of passive and active sensors is critically required.

The early effort to realize this mission was initiated by a team of Goddard Space Flight Center investigators, through a proposal of "Tropical Rain Measuring Mission" in 1984 and was further discussed during the first major workshop in November 1985 near Goddard. In 1986, a group of scientists called TRMM Science Steering Panel led by Dr. E. Rasmusson establish the goals of TRMM to improve the climate models and as an aid to the climate prediction [3]. Although the TRMM is not being launched until 1997, information and explanation on the TRMM have been made available much earlier. One of the examples is from Simpsons *et al.* (1996) whose explained the proposed TRMM satellite based on the first TRMM workshop series, while the later works by Simpson *et al.* (1996) provides details on the TRMM.

TRMM in general is joint project between National Aeronautics and Space Administration (NASA) and Japan Aerospace Exploration Agency (JAXA) whose aims to study the tropical rainfall. The TRMM satellite which consists of passive and active sensors on board had been launched on November 27. 1997 at Tanegashima Island. The satellite observation coverage falls within 35˚ North and 35˚ South of the equator. At each sampling area in the tropics, it is visited about twice daily at different hour of the day or about 16 times orbiting daily (TRMM official website – *trmm.gsfc.nasa.gov*). Initially, the orbital altitude is at 350 km for the purpose of providing fine spatial resolution and highly variable rain fields. However, to maintain its near-constant altitude against the effect of atmospheric drag, the work requires high fuel consumption, and hence, the mission is expected to end around 2003 [4]. However, in August 2001, the TRMM science team worked out an altitude boost by increasing the orbital altitude from 350 km to 402.5 km. as a result, the lifespan of the TRMM satellite is managed to be prolonged. Figure 2.1 shows the TRMM satellite after the altitude boost. Also from the Figure 2.1, it clearly depicted that the TRMM satellite consists of several sensors to measure the rainfall parameters and weather conditions.

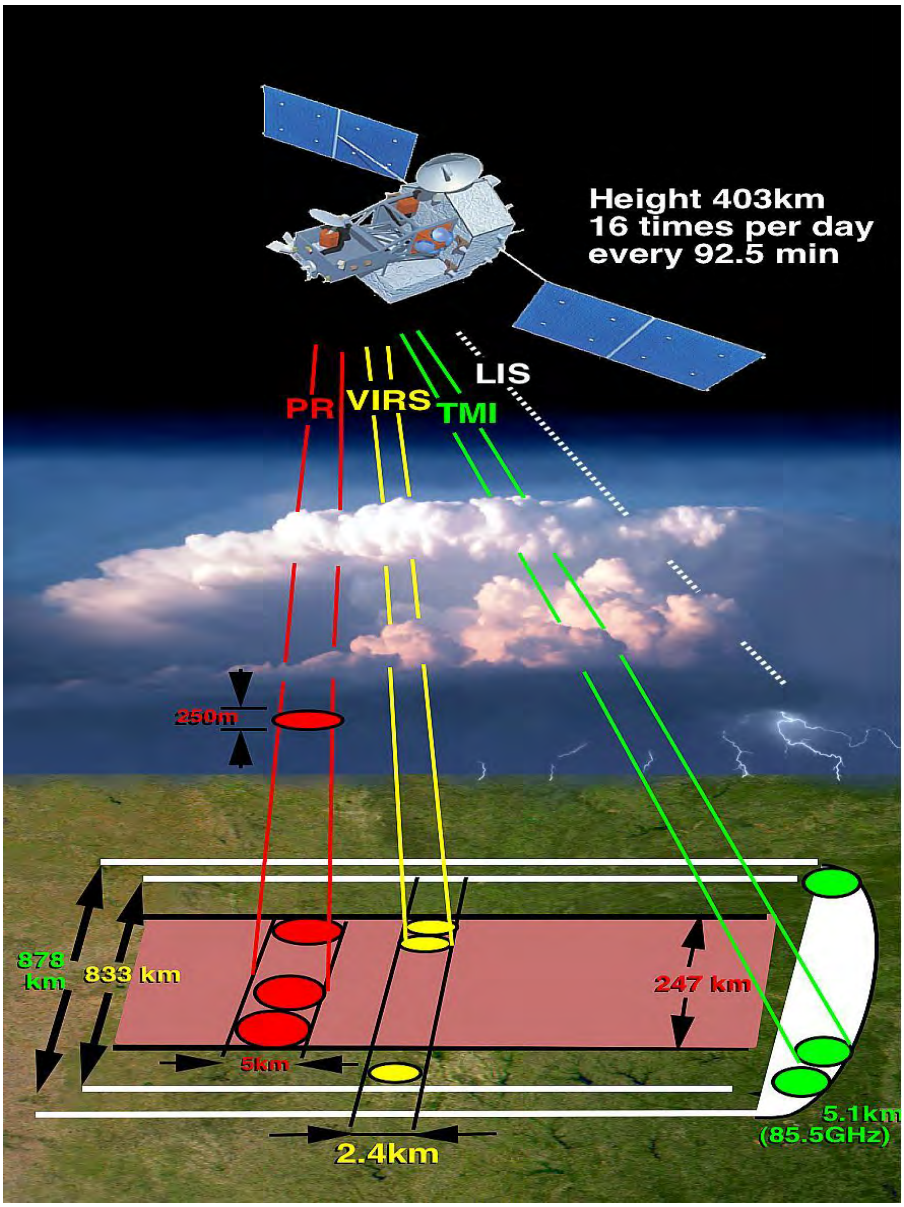

Figure 2.1: TRMM Satellite and The Equipment on Board

Source:[4]

The TRMM instruments have been elaborated in details by Kummerow *et al.* (1998). In the early stage, the TRMM satellite carries along five instruments on boards, each with respective roles and functions. These instruments are known as the Precipitation Radar (PR), TRMM Microwave Imager (TMI), Visible and Infrared Scanner (VIRS), Lightning Imaging Sensor (LIS) and Clouds and Earth's Radiant

Energy System (CERES). However, the CERES instrument failed after eight months of flight.

The TRMM mission has three main sensor packages which involve the three instruments on board. They are the Precipitation Radar (PR), TRMM Microwave Imager (TMI) and Visible and Infrared Scanner (VIRS). Lightning Imaging Sensor (LIS) has its special role to the three main sensor packages as it complemented them to improve the understanding on the convective dynamics and providing climatology of global lightning flash rates. Although CERES failed a few months after being launched, the rest of the instruments are still working almost perfectly with high stability up to this date (May 2014)

2.2.1 Lightning Imaging Sensor (LIS)

The Lightning Imaging Sensor (LIS) is a space based instrument used to detect the distribution and variability of total lightning (cloud-to-cloud, intracloud and cloud to ground lightning) that occur in the tropical regions of the globe. LIS was launched in November 1997 aboard NASA's Tropical Rainfall Measuring Mission TRMM [3].

Lightning Imaging Sensor has developed lightning data achieve that is global in 14 year that preserve at Global Hydrology Resource Center (GHRC) in Huntsville Alabama. GHRC is one of NASA Science data Centre's Earth that run by technology information and system center of UAHuntsville. Attention should be provided for his high resolution space, efficiency detection, coverage and more than ten years period record because it is global lightning that most comprehensive data archive that ever produced.

Society researches had produced all LIS data and may be contacted from GHRC. Area, flash, group and event that arrange LIS data where regional area that is apparent Earth with or more flash at one orbit in awarded. They are meant for roughly correspond to cloud grab respective thunderbolt that the flash is collection