



# THE APPLICATION OF VISIBLE IMAGES FROM METEOROLOGICAL SATELLITE (METSAT) FOR THE RAINFALL ESTIMATION IN KLANG RIVER BASIN

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## ABSTRACT

The flood problem is unpredictable disasters that impose severe effects to the economy, environment, health and to human being. Flood in Malaysia is a common problem due to the climate condition itself. It has causes high amount of rainfall produced throughout the year and formed by monsoon and convective rainfall formation. Therefore, as a solution to the flood problem, an improved technology has to be implemented to control the flood impacts. There are many problem associated with rainfall conventional collecting method as the data obtained not accurate enough due to inexact time, non-functioning stations and disappearance data. The application of Meteorological Satellite (METSAT) visible (VIS) images is the latest technique implement in rainfall estimation and flood forecasting that can contribute a wide area of information in forecasting rainfall depth based on cloud Albedo. This study focuses on the correlating between cloud Albedo and rainfall depth with comparing the rainfall data provided by Department of Irrigation and Drainage (DID) in order to estimate rainfall. From this study, the result obtained from correlation analysis is correlation is equal to 20.4% and a linear law-regression equation;  $y = 0.4239x + 4.18$  for Klang River basin; that can be used to estimate rainfall based on cloud Albedo data from METSAT visible images. It can be summarize that high value of Albedo will contribute higher intensity of rainfall based on the analysis that has been carried out. Therefore, the rainfall estimation equation is still considered reliable in estimating the average rainfall depth for Klang River Basin despite the weak correlation. However, in certain rainfall events, the equations may underestimate the rainfall value due the formation of Albedo that appears only during daytime.

**Keywords:** flood, flood forecasting, satellite, rainfall estimation.

## INTRODUCTION

Malaysia is tropical country that situated in central South-East Asia with high humidity climate. It has an equatorial climate, where it does experience high amount of rainfall throughout the year. The annual mean rainfall is around 3000 mm. The climate in Malaysia is characterized by two monsoons namely Southwest Monsoon from late May to September, and the Northeast Monsoon from November to March. The Northeast Monsoon brings heavy rain especially to the states on the east coast of Peninsular Malaysia and western Sarawak, while the Southwest Monsoon normally signifies relatively drier weather. The northeast monsoon is characterized by persistent winds from the northeast. During this monsoon, the west coast states of Peninsular Malaysia usually having thunderstorms in most places in the afternoons and the evenings. Due to this climate condition, flooding is the most common natural disaster that occurs in Malaysia.

According to Malaysia Meteorology Department (MMD), the occurrence of heavy and widespread rain during November and early December begins in Kelantan and Terengganu. Then, it follows by rain that moves slowly to Pahang and East Johor during December and early January as the monsoon start to progress. Rainfall can be categorized into three different intensities which are low, moderate and high intensity. The basic types of rainfall that cause flood are rainfall with moderate intensity and covering wide area long duration and rainfall with high intensity and short duration localized

rainfall. Many studies have indicates the adverse effect cause by flooding to the economy, environment, health and human being [10-11]. Major effects of floods involved in destruction of life and property or infrastructure such as roads and bridges in urban areas. Besides that, flooding can cause spreading of disease and food poisoning that will cause mortality.

Rainfall estimation and weather forecasting are closely related with flooding problems. Rainfall is one of the most difficult variables to forecast due to its large variability, space and in time [12]. Department of Irrigation and Drainage (DID) responsible to locate station for rainfall and water level daily and hourly monitoring. However, the rainfall and water level station need to be improved as the data obtained not accurate enough due to inexact time, non-functioning stations and disappearance data. Satellite data can provide information covering large areas as well as cloud properties for critical flooded area [3]. There are also many other studies that highlighted the advantages of satellite for rainfall measurement [4, 8, 12]. The satellite infrared images (IR) have been used by most of the researchers to generate the relationship between meteorological data with hydrological data for rainfall prediction. Besides, it has been stated that the analysis on infrared images (IR) are proven to provide better technique for rainfall estimation in order to control flood problems. Flood forecasting system is believes to be improves by this latest technology that combined the meteorological and hydrological field together. Therefore, the application of meteorological satellite (METSAT)



visible images can contribute to better rainfall prediction rather than conventional rainfall measurement.

This study conducted to identify the application of meteorology satellite (METSAT) visible images for rainfall estimation which has contribution to weather forecasting. The weather forecasting system that assigns the weather condition for the study area is an important factor in considering activities. Besides that, visible images from METSAT also has been used in detection of flood forecasting in order to give early warning to public as a precaution of any mishap.

## BACKGROUND OF STUDY

### Meteorological satellite

The meteorological satellites are important and useful for weather forecasting. The condition and properties of cloud can directly be interpreted from meteorology satellite images that can be used for weather prediction and awareness for any hazards that may occur. There are two types of satellite used in viewing the cloud system which are polar satellite orbit and geostationary satellite orbit. Polar satellites travel around the Earth in an orbit over the poles while geostationary satellites travel around orbit over the equator at the same rate with Earth spin which is about at 36,000km height [6].

### History

According to [5], the first satellite in the world is called Sputnik. After three years, the United States of America (USA) launched TIROS-1 (Television and Infrared Observational Satellite) which is the first meteorological satellite in April 1960. Afterward, within six years there is a progress in revolution of TIROS and had produced 10 series of TIROS satellites that used to conduct experiments and observations. First geostationary satellite was launched by USA in year 1966 called ATS-1 for an effective meteorological monitoring. Since then, several of countries had developed a plan for meteorological satellite.

### Multi-Functioning Transport Satellite (MTSAT), Japan

The Multifunctional Transport Satellites (MTSAT) has two purposes, which are for meteorology and aviation control satellites. The satellite is used by Japan Meteorology Agency (JMA) and Aviation control by Civil Aviation Bureau of the Ministry of Land, Infrastructure and Transport. The satellite covers area of East Asia and the Western Pacific regions [6]. The geostationary meteorological satellite has operated since 1978 and this satellite has assisted in data production, which helps to prevent and mitigate disaster that related to weather such as typhoons in the Asia-Oceania region [6]. JMA had replaced the MTSAT-2 (also known as Himawari-7) with Himawari-8 on 7 July 2015 and scheduled to operate until 2022. MTSAT-2 had operated from 2010 until 2015. Another satellite will be launched in 2016, which is known as Himawari-9 will and serve for backup purposes and successor satellite. The position for

both satellite will be around 140° east in the orbit. This satellite will be used for an observation for a period of 15 years for East Asia and Western Pacific regions.

### Visible (VIS) image

Visible image (VIS) represents the sunlight's intensity reflected whether from clouds or the surface of earth [5]. Thus, the condition of oceans, land and clouds is possible for monitoring purposes. The VIS cannot be access during night time, but is it useful for low clouds detection [7]. VIS and Infra-red images measurement contribute to the physical characteristics of clouds and it does provide indirect information on precipitation [2]. Albedo is the amount of object's reflectivity which is depending on the object surface, texture and colour. In general, snow surface does represent bright cloud because have high reflectance (high Albedo) while the land and sea surface are darker due to the low reflectance (low Albedo).

Albedo is measured in percentage and highest percentage represents high reflectance from sunlight [1]. There are many factors that affect the cloud reflectance which are the amount of raindrops and the density of cloud droplets that contains in cloud. There are larger amount of cloud droplets and raindrops found in low-level clouds. Thus, it appears brighter than higher level clouds. Cumulonimbus is related to the strong convective precipitation [7]. VIS image appears bright where in this condition is due to the high amount of cloud droplets and raindrops. Texture of the cloud determined the types of cloud. Top surface of stratiform cloud are smooth and uniform while for convective cloud, the top surface are rugged and uneven.

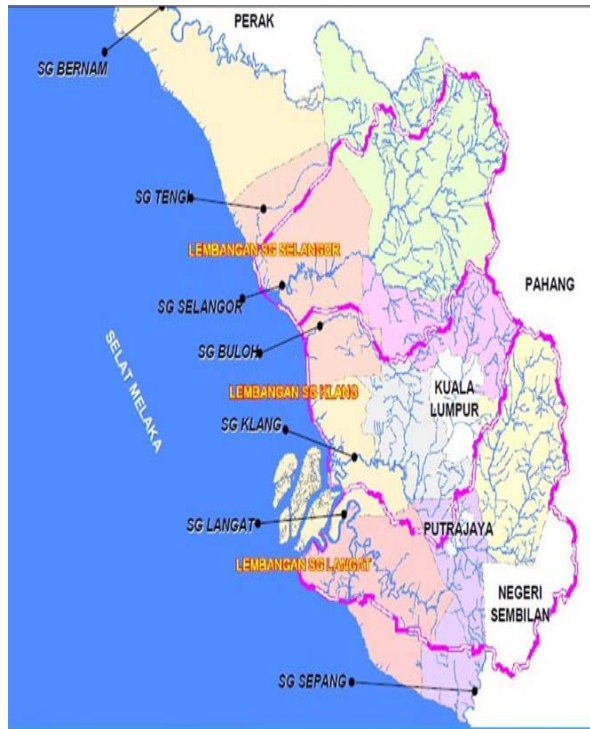
## METHODOLOGY

### Case study of Klang River Basin

Klang River Basin has a total length about 120 km. The catchment area of the Klang River Basin is 1,288 km<sup>2</sup>. The main tributaries are Gombak River (about 27 km long) and Batu Rivers about 24 km long. Klang River basin receives an annual mean rainfall ranges from 1,900 mm to 2600mm.

### Analysis of Albedo of the visible satellite images (VIS)

Hydrological and meteorological data are applied by correlating the rainfall data from rain gauge with the cloud thickness (Albedo) visible images from MTSAT satellite. The satellite images from the study areas were analysed through the cloud's thickness and used for rainfall estimation. Then, the correlation for the both variable was generated by using the regression analysis. In this study, the satellite visible images (VIS) have been used to create a relationship with rainfall data from rain gauge at rainfall stations in Klang River basin for year 2009.



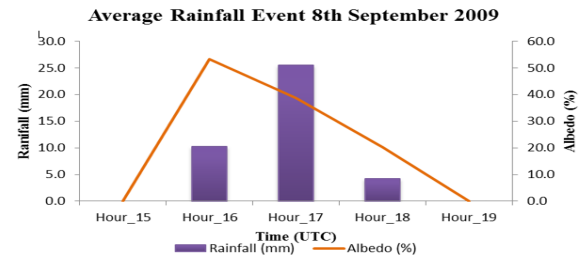
**Figure-1.** Geographical map of Klang River Basin and its neighboring regions [9].

The VIS information is produced by Multi-Functioning Transport Satellite (MTSAT-1). The VIS has been analysed in term of Albedo value based on the cloud brightness. Hourly, Albedo for each coordinate of rainfall stations is selected based on rainfall event for year 2009. Analysis of the Albedo value and rainfall rain gauge data is used to generate rainfall estimation. There are two methods that have been used to indicate the relationship between rainfall and Albedo. The first method is by using the average amount of rainfall and Albedo based on number of rainfall station involved. The second method is by using hourly data of rainfall and Albedo for selected rainfall stations.

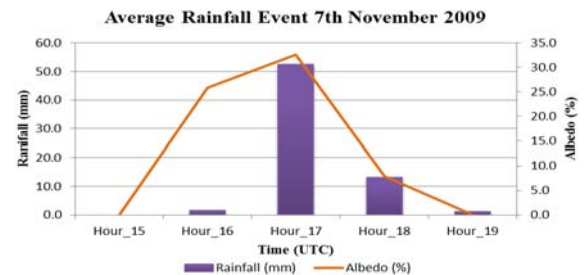
## RESULTS AND ANALYSIS

### Analysis between Albedo of the visible satellite images with rain-gauged data

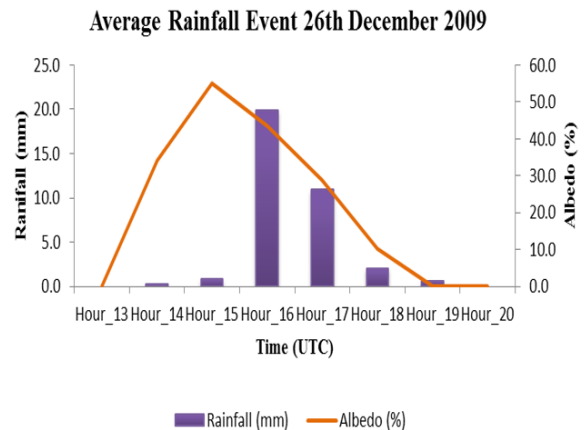
The relations between Albedo of the VIS and rainfall recorded by the rain gauge has been demonstrated in Figures 2-4 for total average rainfall event on 8<sup>th</sup> September 2009, 7<sup>th</sup> November 2009 and 26<sup>th</sup> December 2009. All the corresponding graphs shows there are a decrease trend for the rainfall after it hits the point, where Albedo value is the highest. The Albedo value is at highest point where the rainfall depth is at maximum value. Rainfall event in Klang River Basin mostly received by rainfall from the convective precipitation.



**Figure-2.** Albedo plotted as function of the rainfall depth versus time on 8<sup>th</sup> September 2009-total average rainfall and Albedo.



**Figure-3.** Albedo plotted as function of the rainfall depth versus time on 7<sup>th</sup> November 2009-total average rainfall and Albedo.



**Figure-4.** Albedo plotted as function of the rainfall depth versus time on 26<sup>th</sup> December 2009-total average rainfall and Albedo.

### Comparison between rain-gauged rainfall data with rainfall estimation equation

The correlation was derived between the Albedo and rainfall depths for selected event period (Figure-5). The plotted data represent the average rainfall and average Albedo for all rainfall events in that area. From Figure-5, it indicates that the correlation is equal to 20.4% between Albedo and rainfall depth for Klang River basin. Equation. (1) shows the derived linear-law regression equation for Klang River Basin obtained from the correlation analysis.

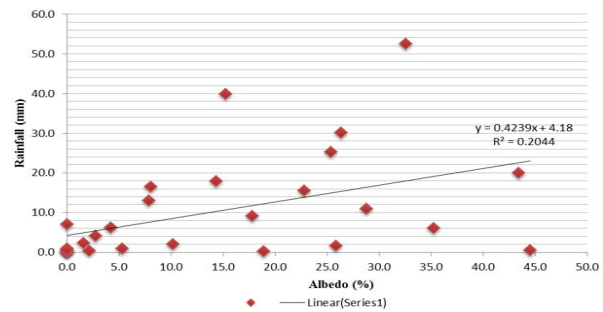
$$y = 0.4239x + 4.18 \quad (1)$$

where y = rainfall depth (mm) and x = Albedo (%).



From Table-1, it indicates for selected events that on 3<sup>rd</sup> March, 18<sup>th</sup> August and 8<sup>th</sup> September 2009 the average rain-gauged data was recorded at 25.3, 15.5 and 25.6 mm/h while the average estimation by using the equation,  $y = 0.4239x + 4.18$  was calculated as 22.06, 13.86 and 20.59 mm/h. Thus, the standard error between both data is 12.81%, 10.58% and 19.57%.

Therefore, the rainfall estimation equation is still considered reliable in estimating the average rainfall depth for Klang River Basin even though it has a weak correlation between both parameters. However, in certain rainfall events, the equations may underestimate the rainfall value due the formation of Albedo that appears only during daytime and this might be the reason of the weak correlation.



**Figure-5.** Correlation between Albedo (%) and Rainfall depth (mm) for Klang River Basin.

**Table-1.** Comparison of rain-gauged data rainfall with rainfall estimation equation.

Location	Date	Ave. rainfall data (mm/h)	Ave. estimation (Equation) mm/h	Error (%)
Klang River Basin	3rd March	25.3	22.06	12.81
	18th August	15.5	13.86	10.58
	8th September	25.6	20.59	19.57

## CONCLUSIONS

It may be realized that meteorological satellite (METSAT) visible images has contribute a wide area of information in rainfall depth forecasting rainfall based on Albedo value. In addition, the application of both aspects which are meteorological and hydrological used in this study had provided a new dimension for weather forecasting system in Malaysia especially regarding flood forecasting purposes. In this study, the application of satellite images can be as a preliminary analysis for early prevention and awareness to public in regards the hazard cause by the flooding problems.

It can be summarize that high value of Albedo will contribute higher intensity of rainfall based on the analysis that has been carried out. In addition, the estimated average rainfall depth based on Albedo was achieved by applying the derived equations that has been generated from the correlation analysis. The application of meteorological satellite (METSAT) visible (VIS) images in Malaysia is the latest technology that has been implemented for the weather forecasting. However, in future, the application of this technology for weather forecast still requires more study to expand the usage of VIS with infrared (IR) images; more datasets is required for verification of the equation derived.

It is believed that the application of visible images in weather forecast can provide better forecast in future.

## ACKNOWLEDGEMENT

The authors would like to express our deepest gratitude to the Ministry of Higher Education Malaysia (MOHE) Fundamental Research Grant Scheme (FRGS) (FRGS/1/2015/TK01/UITM/02/10) and the Research

Management Centre (RMC) UiTM for providing us with the financial support. We also would like to extend our thanks to Malaysian Meteorological Department (MMD) and Drainage and Irrigation Department (DID) for providing us with the research guidance.

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