THE CONSTRUCTION OF MATHEMATICAL TIME FUNCTIONS FOR STORM EVENTS

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To my beloved

parents

Mohd Arish @ Arshad Bin Ismail

and

Foziah Binti Haji Sidek

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ABSTRACT

The main objective of applying statistics in rainfall analysis deals with interpreting a past record of rainfall events, the derivation of information from these observed past hydrologic phenomena and making inferences for the future purpose. Rainfall cannot be predicted with certainty. Therefore statistical analysis is important so that the information received is more easily to understand.The objective of this study is to construct the structure of the time functions of storm between storm and time functions of storm between peaks for Wilayah Persekutuan Kuala Lumpur. From this result, we can simulate or generate the information of time between storms and time between storm peaks. The data for this study was obtained from Department of Irrigation and Drainage of Wilayah Persekutuan Kuala Lumpur. The study area involved 13 stations. Rainfall data is from the year 2000 till 2001. Analysis was done using regression analysis. The data showed that all of them are nonlinear. Two models were used, the exponential model and logarithm model. Most of the results showed that logarithm model performed better result compared to exponential model. All analysis was done using Microsoft Excel.

ABSTRAK

Objektif utama pengaplikasian statistik di dalam analisis hujan adalah berhubung dengan menerangkan rekod hujan pada masa lalu, kepelbagaian maklumat daripada fenomena hidrologi yang lalu dan membuat rujukan daripadanya bagi tujuan masa hadapan. Hujan tidak dapat diramal dengan tepat. Dengan itu analisis statistik adalah penting supaya maklumat yang diterima lebih mudah difahami. Tujuan kajian ini adalah untuk membina struktur bagi fungsi – fungsi masa untuk hujan ribut bagi kawasan Wilayah Persekutuan Kuala Lumpur. Daripada keputusan ini, maklumat tentang masa di antara ribut hujan dan masa puncak antara satu ribut hujan ke satu ribut hujan dapat diperolehi. Data untuk kajian ini telah diperolehi daripada Jabatan Pengairan dan Saliran Wilayah Persekutuan Kuala Lumpur. Kawasan kajian melibatkan 13 stesen kesemuanya. Data hujan adalah dari tahun 2000 hingga 2001. Kajian telah dilakukan menggunakan analisis regresi. Data menunjukkan kesemua data yang diperolehi adalah tidak linear. Dua model telah digunakan iaitu Model Eksponen dan Model Logarithma. Hampir keseluruhan keputusan menunjukkan bahawa Model Logarithma mempersembahkan keputusan yang lebih baik berbanding Model Eksponen. Semua analisis telah dijalankan menggunakan Microsoft Excel.

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SYMBOLS AND ABBREVIATIONS

α	Intercept/regression parameter
α_0	slope of the line/regression parameter
$\hat{\alpha}$	least square estimate of the parameter α
$\hat{\alpha}_0$	least square estimate of the parameter α_0
β	regression coefficient
CV	coefficient of variation
e	error, prediction error or residual
$\hat{e}$	fitted residual
f(x)	regression function
$\hat{f}(x)$	fitted regression function
$f(x,\theta)$	nonlinear regression function
GOM	Government of Malaysia

IDF	Intensity-duration frequency
Θ	Parameter space
x	Independent variable
y	Dependent variable
Δt	interval of time
ε	Random disturbance or error

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CHAPTER I

INTRODUCTION

1.1 Background

The history of hydrology in Malaysia dates back to the latter part of the 19th Century when the first rainfall station was set up in Kuching, Sarawak, in 1876. Hydrology played an increasingly important role in the assessment and development of the country's water resources. However, it was only in 1972, when hydrology was made a function of the Department of Irrigation and Drainage, that hydrological activities were carried out in a more structured and systematic manner. By 1985, the hydrological network had been upgraded to meet the standards of the World Meteorological Organisation. The national network now totals 1,358 rainfall stations, 115 evaporation stations, 219 stream flow stations, 108 river suspended sediment stations, 1,328 river quality stations and 13 agro-hydrological stations.

1.2 Background Problem

Rainfall in Peninsular Malaysia occurs randomly and inconsistent. Hence rainfall must be studied to analyze its behavior and characteristics. Statistical methods are an integral part of water resources research. Many research works are done in developing innovative and more efficient methods for handling data and using them for extrapolating into the future.

Statistical analysis can give an accurate results. Using statistics, any information can be analyzed and easily understood for making predictions of its behaviour. The research undertaken is a statistical analysis on rainfall in Kuala Lumpur, Peninsular Malaysia.

1.3 Study Objectives

a) To study mathematical time functions of storm between storm.
b) To study mathematical time functions between storm peaks.

1.4 Scope of study.

The scope for this statistical analysis of rainfall is only limited to the region of Kuala Lumpur. This is because the data achieved here has been established for a long time.

The data is taken from Department of Irrigation and Drainage of Kuala Lumpur. The data given will be analysed using statistical package. In this research, Microsoft Excel will be used for the analysis.

1.5 The importance of the study.

i) To identify the structure of the time functions of storm between storm and time functions of storm between peaks.

ii) From this result, we can simulate or generate the information of time between storms and time between storm peaks.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Malaysia falls within the humid tropics[1] and has a climate which is equatorial and greatly influenced by both the north-east and the south-west monsoons. The monsoons typically bring heavy rainfall while convectional rain is common during the inter-monsoonal periods. The average annual rainfall amounts to some 3,000 mm, but there is considerable temporal and spatial variation, with highest rainfall exceeding 5,000 mm and the lowest at about 1,750 mm.

The average temperature ranges from 32° C during the day to 21° C at night with very little monthly variation, and relative humidity remains fairly constant at 80 %. The mean open water evaporation varies from 1600 to 1800 mm per annum.

Malaysia is rich in water resources, receiving an annual average of 990 billion m^3, of which 360 billion m^3, or 36 % returns to the atmosphere as evapo-transpiration, 566 billion m^3, or 57 % appears as surface runoff and the remaining 64 billion m^3, or 7 % goes to recharge groundwater [GOM, 1982].

2.2 Rainfall.

Precipitation is an input quantity in hydrologic cycle. The precipitation of water vapor from the atmosphere occurs in many forms, the most important of which are rain and snow. The formation of precipitation usually result from the lifting of moist air masses within the atmosphere, which results in the cooling and condensation of moisture. The four conditions that must be present for the production of precipitation are:

i) cooling of the atmosphere
ii) condensation of water droplets onto nuclei
iii) growth of water droplets
iv) mechanisms to cause a sufficient density of the droplets.

Rainfall amounts are described by the volume of rain falling per unit area and is given as a depth of water. The unit for rainfall depth is millimeter (mm). Rainfall is influenced by weather and physical factor of that place. Rainfall is very related to storm event analysis. A storm was defined as a rain period separated from a preceding and succeeding rainfall by 1 hour or more.

Rainfall is typically measured using rain gages. There are two types of rain gages that are manual recording gages and automatic recording gages. The accuracy of both manual and automatic-recording rain gages are typically on the order of 0.25 mm (0.01 in.). Rain gage measurement are actually point measurements of rainfall and may only be representative of a small area surrounding the rain gage. Areas on the order of 23 km2 (10 mi^2) have been taken as characteristic of rain gage measurements(Gupta, 1989; Ponce, 1989), although considerably smaller characteristic areas can be expected in regions where convection storms are common.

Rainfall measurements are seldom used directly in design applications, but rather the statistics of the rainfall measurements are typically used. The most common form of presenting rain rail statistics is in the form of *intensity-duration-frequency* (1DF) curves, which express the relationship between the intensity in a rainstorm and the averaging time (= duration), with each relationship having a given return period. To fully understand the meaning and application of the IDF curve, it is best to review how this curve is calculated from raw rainfall measurements. The data required to calculate the IDF curve is a record of rainfall measurements in the form of the depth of rainfall during fixed intervals of time, Δt, typically on the order of 5 minutes. Local rainfall data are usually in the form of daily totals for nonrecording gages, with smaller time increments used in recording gages.

Table 2.1 : Rainfall classification and depth.

Rainfall classification	Rainfall depth (mm/min)
Weak rainfall	< 0.02
Very heavy rainfall	0.02 – 0.05
Normal rainfall	0.05 – 0.25
Rapid rainfall	0.25 – 2
Very rapid rainfall	> 1

Table 2.2: Rainfall condition and depth

Rainfall condition	Rainfall depth (mm)	
	1 hour	2 hour
Very light rain	< 1	< 5
Light rain	1-5	5 – 20
Normal rain	5 – 20	20 – 50
Heavy rain	10 – 20	50 – 100
Very heavy rain	> 20	> 100

2.2.1 Rainfall In Malaysia.

Malaysia has a tropical climate with high temperatures and rainfall all year round. Rainfall is heavy and usually occurs in the form of thunderstorms. The main differences of climate within the country are due to differences of altitude and the exposure of the coastal lowlands to the alternating northeast and southwest monsoon winds. Southwest monsoon winds blow from April- September while the northeast monsoon occurs from November-February. March and October are the transition months between the monsoons, characterized by light and variable winds. The seasonal wind flow patterns coupled with the local topographic features determine the rainfall distribution patterns over the country. During the northeast monsoon season, the exposed areas like the east coast of Peninsular Malaysia, Western Sarawak and the northeast coast of Sabah experiences heavy rain spells. On the other hand, inland areas or areas which are sheltered by mountain ranges are relatively free from its influence.

2.2.2 Storm rainfall.

Storm rainfall event is defined as the total rainfall depth of event exceeding 10 mm.

i) **Storm depth and duration**. Storm depth and duration are directly related. Storm depth increasing with duration. An equation relating storm depth and duration is

$$h = ct^n \qquad \text{Equation 2.1}$$

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