EVALUATION OF RAIN CELL MODELS USING INDONESIAN METEOROLOGICAL RADAR DATA

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A project report submitted inpartial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Eletrical-Electronics & Telecommunications)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

JUNE 2015

Specially dedicated to *Abi Adib, Mama,* and *Papa*

Thanks for all of your support.

ACKNOWLEDGEMENT

Assalamulaikum;

I want to express my full appreciation to my supervisor, Dr. Nor Hisham Hj. Khamis for the guidance,commentary and encouragement. His support makes the thesis can be completed.

I am very thankful to Mak Fiah and Ibu Lena for their assistance while helping me in Johor.

Finally, to all my family members in Padang, Sumbar Indonesia. Thank you for all your support to finish my thesis successfully.

ABSTRACT

Frequencies above 10 GHz are strongly affected by attenuation phenomena due to atmospheric impairments, among which rain plays the dominant role. Horizontal structure of rain fields is very complex due to its high space-time variability. Considering modelled cells which are described by a small number of parameters that would allow reduced computing time, storage problems, and multiply the system simulations to optimally define the system parameters. Radar image with range bin pixel up to 200 m, 0.5 degrees of elevation angle and about 100 km from radar site. Peak of rain intensity and the distances along elliptic shape of rain cells can obtained and also each model parameters. The EXCELL and HYCELL model has been fitted and compared to every rain cell. The result shows HYCELL model has good performance than EXCELL model.

ABSTRAK

Frekuensi melebihi 10 GHz amat dipengaruhi oleh fenomena pengecilan disebabkan gangguan atmosfera, antaranya hujan memainkan peranan yang dominan. Struktur mendatar bidang hujan adalah sangat kompleks kerana tinggi kepelbagaian ruang-masa. Memandangkan sel dimodelkan yang digambarkan oleh sebilangan kecil parameter yang akan membolehkan masa pengkomputeran dikurangkan, masalah penyimpanan, dan membiak simulasi sistem secara optimum menentukan parameter sistem. Imej radar dengan pelbagai bin piksel sehingga 200 m, 0.5 darjah sudut ketinggian dan kira-kira 100 km dari tapak radar. Puncak keamatan hujan dan jarak di sepanjang bentuk elips sel hujan boleh diperolehi dan juga setiap parameter model. The EXCELL dan HYCELL model telah dipasang dan dibandingkan dengan setiap sel hujan. Hasil kajian menunjukkan model HYCELL mempunyai prestasi yang baik dari pada model EXCELL.

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LIST OF ABBREVIATIONS

RADAR	-	Radio Detecting and Ranging
BMKG	-	BadanMeteorologiKlimatologidanGeofisika
FMT	-	Fade Mitigation Technique
CW	-	Continous Wave
PRF	-	Pulse Repetition Frequency
Z	-	Reflectivity
dBZ	-	Decible reflectivity
ITU	-	International Telecommunication Union
ITU-R	-	International Telecommunication Union - Recommendations
R	-	Rain Rate
R_E	-	The EXCELL modeled rain-intensity mean value
a_E,b_E	-	Distances along the O_x and $O_y$axes exponentially decay
Rr	-	The mean measured intensity in the cell
R_G,	-	The HYCELL modeled rain-intensity mean value
a_G, b_G	-	Distances along the O_x and $O_y$axes for Gaussian component
R_1	-	Separates Gaussian and Exponential Component

R_2	-	Rain Rate threshold
R_{rms}	-	Normalized rain-intensitythe root mean square
G	-	Mean value of horizontal rain intensity gradient
G_{rms}	-	The horizontal rain intensity gradient the root mean square
A_r	-	Area of rainy pixels
e_r	-	Ellipticity of the cell

LIST OF SYMBOL

ξ	-	The average rain intensity error

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Rain attenuation is the most significant atmospheric impairment for radio-communication systems operating at frequencies above 10 GHz (Capsoni, et al., 2006). A good knowledge of the structure of rain cells is important in the modeling of rain-induced propagation effects, this kind of experimental work can be performed only at few geographical locations, and for a limited number of frequencies and link geometries. Still, telecommunication system are expected to provide real time multimedia services, and consequently, to be reliable and guarantee the desired system availability.

Strong signal fades can no longer be overcome by making use of static power margins, but require the application of Fade Mitigation Techniques (FMTs) as a viable solution. Such as Dynamic resource allocation from onboard antenna of satellite (Paraboni et al., 2007) and site diversity are based on the knowledge of the rain fall spatial distribution (Goldhirsh et al., 1997).

Weather or meteorological radar data represent a valuable alternative in order to assess the performance of a desired FMT, as they inherently reflect the influence of the local climatology and topography on the rain field

spatial distribution. The lack of worldwide comprehensive and reliable precipitation data has pushed towards the development of models aiming to represent at best the characteristics of the local rainfall process (Luinin and Capsoni, 2009).

Rain field modeling proposed among the various approaches so far in meteorological, statical, stochastic, fractal models and relying on the cellular representation of the rainfall process such as EXCELL and HYCELL are particularly suitable for the analysis of the issues related to the radio propagation through the atmosphere (Luini and Capsoni, 2009).

Tropical region suffers from heavy rainfall rates as compared to temperate regions. Such as Indonesia, rainfall region consist of 3 types such as Monsoon, Equatorial, and Local (Aldrian E., 2003). Department of Meteorological, Climatology and Geophysics of Indonesia (BMKG) operated 24 C-Band radars. This project used C-Band radar data of BMKG Kemayoran Jakarta.

1.2 Problem Statement

The followings are the problem statements for this project:-

i. Telecommunication links operating at frequencies above 10Ghz are strongly affected by attenuation phenomena due to atmospheric impairments, the application of Fade mitigation Technique (FMT) become a viable solution.

ii. Site diversity based on the knowledge of the rainfall spatial distribution, rain cell models represent the characteristics of the local rainfall process.

iii. Short-term forecasting of rain rate to derive estimate of rain-field attenuation, this can increase system uptime.

1.3 Research Objectives

The objectives of the project are:

i. To study available rain cell models.

ii. To compare the suitable of each models using meteorological radar data.

iii. To choose and improve the most suitable rain cell size model for tropical country e.g. Indonesia.

1.4 Scope of Work

The scope of study indicates the basic guidelines and techniques that this study examined in achieving the objectives. It also ensures that the work done stays within the intended study. Radar data gives the rainfall rate for a range-bin of 200 m each, up to 100 km. The Radar data is obtained from weather radar Doppler C-Band Kemayoran Jakarta Indonesia.

1.5 Thesis Outline

This thesis is systematized in FIVE (5) chapters. Chapter One gives an overview and the introduction of the project.

Chapter two consist of literature review of the study, fundamental of RADAR by focusing on beam spreading and base reflectivity, equation target of weather or meteorological data which is used in this project.

Chapter three discussed about the methodology of the project. Radar data format, determine the rain fall rates, and determine the rain cell models.

Chapter four represents the result and data analysis. Then, compare between models which one is suitable for local area.

Chapter five concludes the results and suggest for future study.

1.6 Summary of Work

The project schedule shows in Figure 1.1. The project begins with the literature review, followed by doing selecting data, simulation and evaluated the models parameters using Matlab. The final step is presentation and thesis writing.

PROJECT SCHEDULE															
MONTH	FEBRUARY			MARCH				APRIL				MAY			
WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Research on related topic															
Literature review															
Methodology study															
Presentation															
Report writing															

MONTH	FEBRUARY				MARCH				APRIL				MAY			
WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Collecting Data																
Simulations on MATLAB																
Presentation																
Thesis writing																

Figure 1.1: Project schedule.

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