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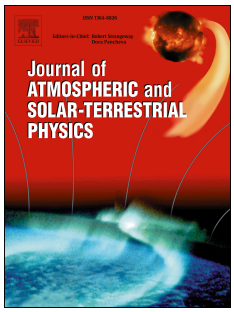

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PERFORMANCE ANALYSIS OF 60-MIN TO 1-MIN INTEGRATION TIME RAIN RATE CONVERSION MODELS IN MALAYSIA

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ABSTRACT
Utilizing the frequency band above 10 GHz is in focus nowadays as a result of the fast expansion of radio communication systems in Malaysia. However, rain fade is the critical factor in attenuation of signal propagation for frequencies above 10 GHz. Malaysia is located in a tropical and equatorial region with high rain intensity throughout the year, and this study will review rain distribution and evaluate the performance of 60-minute to 1-minute integration time rain rate conversion methods for Malaysia. Several conversion methods such as Segal, Chebil & Rahman, Burgeono, Emiliani, Lavergnat and Gole (LG), Simplified Moupfouma, Joo et al, fourth order polynomial fit and logarithmic model have been chosen to evaluate the performance to predict 1-minute rain rate for 10 sites in Malaysia. After the completion of this research, the results show that Chebil & Rahman model, Lavergnat & Gole model, Fourth order polynomial fit and Logarithmic model have shown the best performances in 60-minute to 1-minute rain rate conversion over 10 sites. In conclusion, it is proven that there is no single model which can claim to perform the best across 10 sites. By averaging RMSE and SC-RMSE over 10 sites, Chebil and Rahman model is the best method.

Keywords: 1-min Integration Time Rain Rate; Conversion Models; Tropical Region; Rain Rate distribution.

1. INTRODUCTION

Rapid development of technology for wireless communication above 10 GHz, is important to resolve the crowding of the currently used frequency bands. This is particularly important in developing countries such as Malaysia. Telecommunication system engineers seek for Ku-band (12/14 GHz) because of its advantages of wider spectrum availability, higher data transfer and smaller antenna size (Owolawi et al., 2009). However, rain fade is the most critical factor of signal degradation when analysing satellite communication links at frequencies above 10 GHz. Rain affects the transmission of an electromagnetic signal by increasing the system noise temperature, attenuating the signal and changing in polarization. These three mechanisms cause degradation in the signal quality received. When the frequency increases, the signal strength deteriorates and rain drops affect the signal propagation (Ooi et al., 2013).

According to International Telecommunication Union (ITU-R P837-6, 2012), 1-minute rain rate statistics are required to estimate the rain influenced fade effect on the propagation rate. 1-minute integration times ensures that the peaks of rain event are sufficiently experimented and the use of longer integration times would result in an averaging effect (as the rain rate would be the average of accumulation over a longer time interval), causing high intensity rain rate value to appear low (Emiliani et al., 2008). Yet long term basis of 1-minute integrated rainfall data is insufficient in Malaysia. As a result, an effective conversion method for rain rate is necessary to predict a precise 1-minute rain rate distribution (Mandeep et al., 2008).

Malaysia is a tropical country where precipitation occurs throughout the year, particularly during monsoon seasons. There were several local studies conducted to understand conversion process of rain rate distribution from higher integration times into 1-minute in Malaysia. From the studies done by J.S. Mandeep, et al. (2008), Segal method is the best conversion models when applied to Southeast Asia and Kuching (Mandeep et al., 2008). Chebil & Rahman applied Segal's method to convert 60-minute and 1-minute rain rate in Malaysia and published conversion method by modified Segal model in year 1999 (Chebil and Rahman, 1999). Selamat et al. (2014) did comparison among 5 existing conversion methods for converting 60-minute to 1-minute on 5 sites of East Malaysia and the result shows Segal method gave the best performance among 5 methods: Segal, Burgueno et al, Emiliani et al, Chebil and Rahman, ITU-R P.837-6 Annex 3 (Selamat et al. 2014).

Here we present the analysis of 1-minute and 60-minute rain rate statistics observed from a 4-year (year 2010 – 2013) measurement at 10 locations from Peninsular of Malaysia and East Malaysia. There are 9 rain rate conversion models selected to convert 60-minute to 1-minute integrated time. The performance analysis over the conversion models and rain rate models are evaluated in this paper. The study is important to understand the performance of existing models and to look for the suitable models to be used in the selected areas in Malaysia.

2. OVERVIEW OF CONVERSION METHODS FOR RAIN RATE DISTRIBUTION

The conversion methods can be categorized into 3 groups: physical, analytical and empirical method. Most of the researchers tend to use the empirical method extensively to convert from higher integrated time to lower equivalent due to its simplicity and experiment dependent (Emiliani et al., 2009). The proposed conversion methods used in this paper are Segal method