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"Perspectives on Innovative Sciences"

FACULTY OF MATHEMATICS AND NATURAL SCIENCES,
BOGOR AGRICULTURAL UNIVERSITY
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FOREWORD

The International Seminar on Sciences 2013, which had the main theme "Perspectives on Innovative Sciences", was organized on November 15^{th} -17^{th}, 2013 by the Faculty of Mathematics and Natural Sciences, Bogor Agricultural University. This event aimed at sharing knowledge and expertise, as well as building network and collaborations among scientists from various institutions at national and international level.

Scientific presentations in this seminar consisted of a keynote speech, some invited speeches, and about 120 contributions of oral and poster presentations. Among the contributions, 66 full papers have been submitted and reviewed to be published in this proceeding. These papers were clustered in four groups according to our themes:

A. Sustainability and Science Based Agriculture

B. Science of Complexity

C. Mathematics, Statistics and Computer Science

D. Biosciences and Bioresources

In this occasion, we would like to express our thanks and gratitude to our distinguished keynote and invited speakers: Minister of Science and Technology, Prof. Manabu D. Yamanaka (Kobe University, Japan), Prof. Kanaya (Nara Institute of Science and Technology, NAIST, Japan), Prof. Ken Tanaka (Toyama University, Japan), Emmanuel Paradis, PhD. (Institut de Recherche pour le Développement, IRD, France), Prof. Dr. Ir. Rizaldi Boer, MS (Bogor Agricultural University), and Prof. Dr. Ir. Antonius Suwanto, M.Sc. (Bogor Agricultural University).

We would like also to extend our thanks and appreciation to all participants and referees for the wonderful cooperation, the great coordination, and the fascinating efforts. Appreciation and special thanks are addressed to our colleagues and staffs who help in editing process. Finally, we acknowledge and express our thanks to all friends, colleagues, and staffs of the Faculty of Mathematics and Natural Sciences IPB for their help and support.

Bogor, March 2014

The Organizing Committee

International Seminar on Sciences 2013

Table of Content

D. Biosciences and Bioresources 323

The comparison spatial distribution observed, estimatated using Neyman-Scott Rectangular Pulse Method (NSRP), and simulation for mean of one-hour rain and probability of 24-hour rain

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Abstract

The similarity of spatial distribution on the statistical mean of an hour rain and probability of 24 hour rain, which have resulted from observed data and based on Neyman-Scott Rectangular Pulse (NSRP) model in this research, has ascertained that NSRP's parameters can be applied to simulate both aforementioned statistics. A spatial distribution simulation of the month 11 over 55 rain stations located at Peninsular Malaysia was successfully performed in obtaining its statistics, and it can be seen from the similarity of spatial distribution simulation of both statistics used in spatial distribution based on observed data.

Keywords: Neyman-Scott rectangular pulse, probability of 24 hour rain, similarity of spatial, spatial distribution

1. Introduction

Spatial distribution of rain modeling and stochastic method in hourly rain data are two research majors often conducted over the last ten years. This modelling will be practicable when it is used as early warning for water-flood status, and also be advantageously relevant to recent issues, climate change in particular. Besides that, the issue related to the extreme change of rain patterns also emerge the research of this field become more interesting subject. Some research associated with spatial distribution of various statistics have been performed by some researchers; Collinge and Jamieson (1968) investigated spatial distribution of rain storm, Tolika and Maheras (2005) examined spatial rain sequence in Greek, Dani et al (2008) inspected spatial distribution of rain and no-rain sequence in Peninsular Malaysia. One of popular researchers developing stochastic method of rain modeling was Rodriguez-Iturbe et al (1987), and the study applied clusters on groups of rain in every storm emerging, and every cluster had two parameters; the intensity of rain and the length of raining time. Thus, the study is well known as stochastic modeling using NSRP method. Modeling based on NSRP method often begins with NSRP's parameter definition, and the parameters have been investigated by some following experts such as (Rodriguez-Iturbe et al.,1987a,b; Entekhabi et al.,1989; Cowpertwait, 1991; Calenda dan Napolatino, 1999; Favre et al., 2004). The most common approach to identify NSRP's parameters is the moment method. This method uses scale on various data of rain, and the simplest scale comprises a scale of an hour rain and 24-hour rain, where the scale of both types will be used to produce the first and the second moment of statistical values. The third statistics moment and the dry-probability are other statistics used by most researchers in rain modeling using NSRP method. Some researchers have conducted studies to obtain NSRP's parameters such as Rodriguez-Iturbe et al.(1987a,b). Cowpertwait (1991) added the component of dry-probability in estimating NSRP's parameters. Cowpertwait et al. (1996a,b) applied some statistical rain scales of variances, autocorrelation of lag 2, and autocorrelation of lag 3, dry and transition probability. This research will include spatial distribution simulation over the statistical mean of one hour and rain probability of 24 hours which were resulted by using NSRP's parameters taken from 55 rain stations at Peninsular Malaysia. Some steps in this research are initiated with introduction on the part 1, NSRP modeling will be discussed on the part 2, and the part 3 includes NSRP's parameters definition and simulation methods, and in the following section the outcome of this research consisted of NSRP's parameters of 55 rain stations at

Peninsular Malaysia through simulation and theoretical approach will be explored on the part 4. The statistical values of mean of one hour rain and probability of 24 hour rain are aimed for observed data, and thus, the estimated statistics of NSRP method and other outcomes resulted from simulation process will be discussed on the same section of the part. Finally, the study is closed by conclusion of the research.

2. NSRP Modeling

NSRP modeling initially uses these following conditions;

1. Every storm arrival, which is symbolized as $l_i, i = 1,2,3,...$, is exponentially distributed in poisson process with parameter λ,
2. The amount of random rainfall cells of every, c_{ij}, i = ith storm, j = rain cell at ith storm, has poisson or geometry distribution with mean of $E(C)$,
3. Every counted rain cell of storm arrival b_{ik}, i = ith storm of i, k = time of rain
4. cell at ith storm, will be exponentially distributed with mean β.
5. In every rain cell, there are two other parameters forming cluster as rain cell intensity x_{jh}, j = jth cell, h = intensity at jth cell, which is exponentially distributed with mean $E(X)$, and the duration of rain t_{js}, j = jth cell, s = duration at jth cell, is exponentially distributed with mean η.

Those five conditions can be depicted on the Figure 1 below.

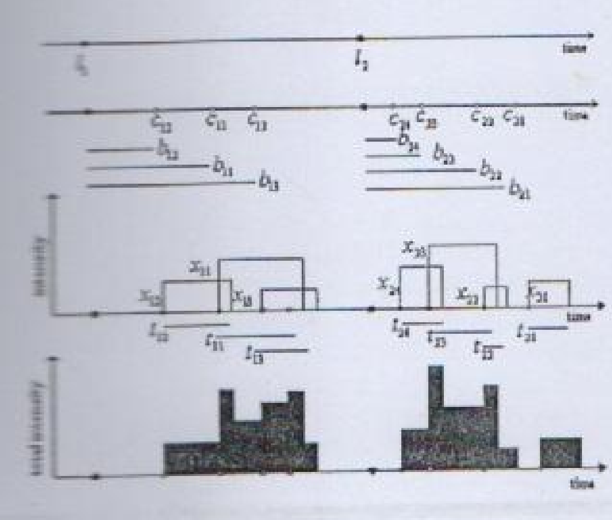

Fig. 1. NSRP modeling, l_i storm arrival time, c_{ij} rain cell, b_{ik} time of rain cell, t_{js} duration of rain cell and x_{jh} intensity of rain cell.

Rodriguez-Iturbe et al.(1987a) applied the formula to produce the first and the second statistical moments (variance and autocorrelation), and probability of succession rain as equation 1 , 2, 3, and 4 used to obtain NSRP's parameters.

$$E\left(Y_i^{(\tau)}\right) = \frac{\lambda}{\eta} E(C) E(X) \tau \tag{1}$$

$$Var\left(Y_i^{(\tau)}\right) = \Omega_1(\lambda, E(C), E(X))\,\Psi_1(\eta,\tau) + \Omega_2(\lambda, E(C), E(X))\,\Psi_2(\beta,\eta,\tau) \tag{2}$$

$$Cov\left(Y_i^{(\tau)}, Y_{i+k}^{(\tau)}\right) = \Omega_1(\lambda, E(C), E(X))\,\Psi_3(\beta,\eta,\tau) + \Omega_2(\lambda, E(C), E(X))\,\Psi_4(\beta,\eta,\tau) \tag{3}$$

$$1 - \Pr\left\{Y_i^{(\tau)} = 0\right\} \tag{4}$$

where

$$\Pr\left\{Y_i^{(\tau)} = 0\right\} = \exp\left(-\lambda\tau + \lambda\beta^{-1}(E(C)-1)^{-1} \omega - \lambda \int_0^{\infty} [1 - p(t,\tau)]\, dt \right)$$

$$p(t,\tau) = \left(\exp[-\beta(t+\tau)] + 1 - \vartheta \right) \times \exp\left(-(E(C)-1)\beta\upsilon/\nu + (E(C)-1)\exp[-\beta(t+\tau)] \right)$$

$$\Omega_1(\lambda, E(C), E(X)) = 2\lambda E(C) E(X^2)$$

$$\Omega_2(\lambda, E(C), E(X)) = \lambda E(C^2 - C) E^2(X)$$

$$\Psi_1(\eta,\tau) = \frac{1}{\eta^3}(\eta\tau - 1 + \exp(-\eta\tau))$$

$$\Xi_2(\beta,\eta,\tau) = \Psi_1(\eta,\tau)\frac{\beta^2}{\beta^2-\eta^2} - \frac{\beta\tau - 1 + \exp(-\beta\tau)}{\beta(\beta^2-\eta^2)}$$

$$\Xi_3(\beta,\eta,\tau) = \frac{1}{2\eta^3}(1-\exp(-\eta\tau))^2 \exp(-\eta(k-1)\tau)$$

$$\Xi_4(\beta,\eta,\tau) = \Psi_3(\beta,\eta,\tau)\frac{\beta^2}{\beta^2-\eta^2} - \frac{(1-\exp(-\beta\tau)^2 \exp(-\beta(k-1))}{2\beta(\beta^2-\eta^2)}$$

k = *autocorrelation of lag 1,2,3*

τ = *rain aggregation*

$$\phi = 1 - \exp\left[1 - E(C) + (E(C)-1)\exp(-\beta\tau)\right]$$

$$= \left[\eta\exp(-\beta t) - \beta\exp(-\eta t)\right] / \left[\eta - \beta\right]$$

$$= \left[\exp(-\beta t) - \exp(-\eta t)\right]$$

$$= \left[\eta - \beta\right] - (E(C)-1)\exp(-\beta t)$$

...me researchers who applied the afformentioned ...ations to gain NSRP's parameter. The procedures ...ining the NSRP's parameters are carried out by ...llowing stapes;

1. Get the rain data of scale one, six and 24 hours.
2. Get all required statistics values; mean for one hour rain, variances for the amount of 1, 6, and 24 hour rain, autocorrelation of lag 1 for the amount of 1 and 24 hour rain, and rain probability for the amount of 1 and 24 hour rain.
3. Use the equation (1), (2), (3), and (4) by applying the total of rain scalling as it was discussed on the stape 2, so that there will be 8 non-linear equations.
4. Optimize the objective of the equation as it is applied on equation (5) numerically to.

raise NSRP's parameters, where $\Theta_k^*(\tau)$ is eight values obtained from step 2, while $\Theta_k(x,\tau)$ is eight equations gained from step 3

$$Z(X) = \sum_{k,\tau}\left[1 - \frac{\Theta_i(X,\tau)}{\Theta_i^*(\tau)}\right]^2 \quad (5)$$

4. Spatial distributian observed , Estimated by NSRP and Simulation for an hour mean and 24 hour rain probability

This research is conducted over 55 rain stations located in Peninsular Malaysia, hourly rain data obtained from the rain statitions will be applied in this study. The rain stations are shown on the figure 2. Then, by applying steps as in the previous discussion on the section 3, the values of NSRP's parameters of month 11 from 5 rain stations can be seen on Table 1.

Table 1 The values of NSRP's parameters of month 11

Rain station name	latitude	longitude	λ	E (x)	E (c)	β	η
Alor Setar	100.39	6.11	0.00650	2.090	16.267	0.113	2.049
ampang	102	3.2	0.00678	5.667	10.946	0.037	2.300
arau	100.27	6.43	0.01047	5.698	16.485	0.054	2.609
baling	100.74	5.58	0.01161	5.035	5.967	0.127	2.388
batuHampar	102.82	5.45	0.01202	12.693	4.338	0.068	3.031

Table 2 The values of NSRP's parameter from simulation of month 11

Rain station name	longitude	latitude	λ	E (x)	E (c)	β	η
alorsetar	100.39	6.11	0.007	2.093	16.289	0.113	2.052
ampang	102	3.2	0.007	5.667	10.900	0.037	2.299
arau	100.27	6.43	0.011	5.707	16.472	0.054	2.612
baling	100.74	5.58	0.012	5.048	5.958	0.127	2.392
batuhampar	102.82	5.45	0.012	12.694	4.338	0.068	3.030

Table 3 The values of observed statistics, estimated by NSRP, and simulation for month 11.

Stesen	MO 1	ME 1	MS1	KO 1	KE 1	KS1
Alor Setar	0.1130	0.1080	0.1081	0.2810	0.2930	0.2925
Ampang	0.1780	0.1830	0.1820	0.4620	0.4490	0.4486
Arau	0.3650	0.3770	0.3783	0.5740	0.5680	0.5692
baling	0.1460	0.1460	0.1461	0.3810	0.3810	0.3806
batuHampar	0.2250	0.2180	0.2180	0.4190	0.4360	0.4357

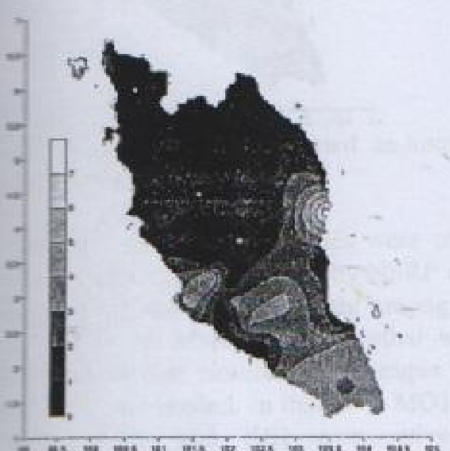

Fig. 2 Spatial distribution of observed an hour rain mean for month 11.

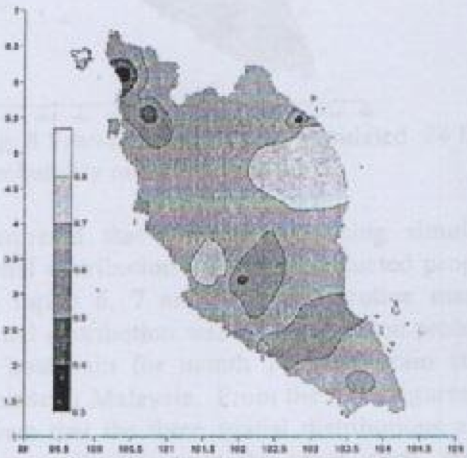

Fig. 3 Spatial distribution of observed 24 hour probability rain for month 11.

From Table 1 can be seen that the intensity rain cell that occurred in 11 can generally be divided into two, namely high intensity rain cells which have an average intensity rain cell greater than 50 mm / hours and low intensity rain cells has an average intensity rain cells smaller than 15 mm / hours. From the table can also be seen that the majority of area in peninsular Malaysia have low rainfall, this is of course an effect on the average rainfall an hour in the area of peninsular Malaysia, this influence can be seen in Figures 3. In this Fig can be seen that most parts of Malaysia has an average rainfall is not so high. Onwards from the same table can also be seen that the average number of rain cells and the average duration of rain cells that occurs is not so low for each hour of rain has resulted in probability rain for every 24 hours to be high enough in the area peninsular Malaysia, this can be seen on Figure 6. Then from the table, it is possible to find new parameters of NSRP via simualtion technique as it as described on the section 3. On the Table 2, NSRP's parameter of month 11 is obtained from simulation run.

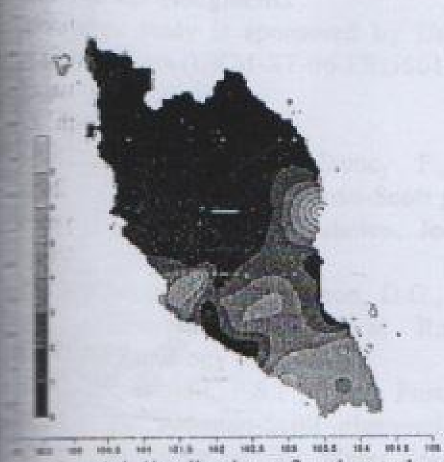

Fig. 4 Spatial distribution of estimated an hour rain mean for month 11.

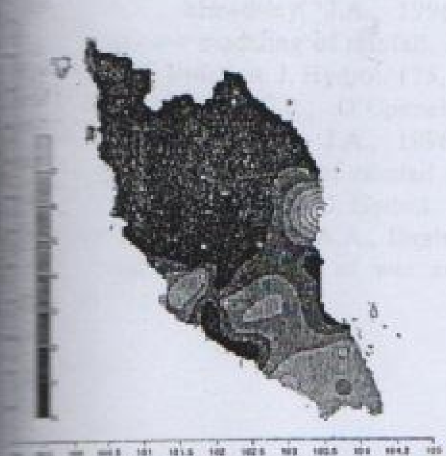

Fig. 5 Spatial distribution of simulated an huor rain mean for month 11

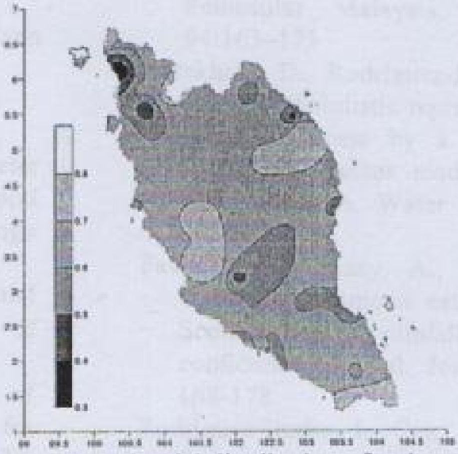

Fig. 7 Spatial distribution of estimated 24 hour probability rain for month 11.

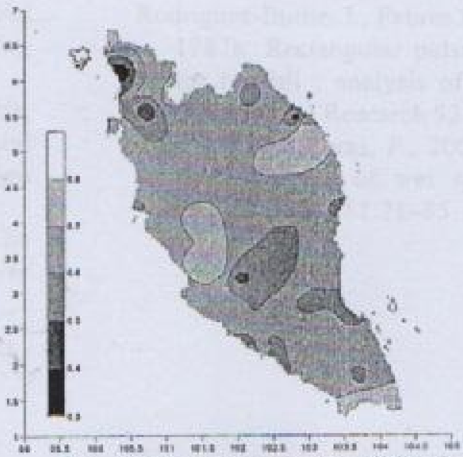

Fig. 8 Spatial distribution of simulated 24 huor probability rain for month 11

In the Table 3, the statistics values were obtained three methods (observed, estimated by NSRP method and Simulation), there is no different among 5 rain station in Peninsular Malaysia, or in other word, it can be concluded that simulation technique in this study sufficently succeeded. In that table MO1, ME1, MS1, KO1, KE1, and KS1 consecutively are observed an hour rain mean, estimated an huor rain mean, simulation an hour rain main, observed 24 hour rain probability , estimated 24 huor rain probability, simulated 24 huor rain probability for month 11 has similar result for almost the whole 5 rain stations of this study. . Inderectly, it lead to the conclusion that simulation technique is applied successfully. The outcome on the table 3 will be used to analyse spatial distribution. From figure 3, 4 and 5 it is clear that the spatial distributions of mean statistics of an hour rain for month 11 over the three methods are almost similar. This fact can be interpreted that the research using simulation on spatial distribution has been conducted properly. On the figure 6, 7 and 8 in consecutive manner, the spatial distribution was also gained on probability of 24 hour rain for month 11 of 55 rain stations in Peninsular Malaysia. From the three figures above is shown that the three spatial distributions as outputs have similarities with the other word, technically, simulation approach is performed successfully.

Conclusion

Research in spatial distribution simulation in months of mostly raining occurence over 55 rain stations in Peninsular Malaysia, month 11 and 12 in particular for statistics of an hour rain mean and probability of 24 hour rain has given appropriate outcome. This can be identifyed from the similarity of spatial distribution for statistics which is from real data and as well as simulation technique.

Acknowledgments

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