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Neyman Scott Rectangular Pulse (NSRP) Modeling and Spatial Analysis of Storm Behavior in Peninsular Malaysia

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Abstract: Nowadays, the analysis of rainfall behavior is becoming important in many areas, particularly in water-related sectors such as hydrology, agriculture and water resource management. The expansion of irrigated agriculture, coupled with the development of industrialization and the rapid growth of population, contribute to the demand for the analysis of rainfall behaviour as such analysis can be utilized in rainfall forecasting and decision making. The main objective of this study is to evaluate the application Neyman-Scott Rectangular Pulse (NSRP) modeling in describing the storm rainfall in Peninsular Malaysia. This study also describing spatial analysis for the important statistics (mean and probability rain) and the storm behavior by using NSRP parameters in Peninsular Malaysia, based on hourly rainfall data from 50 selected rainfall stations which include four sub regions, namely Northwest, West, Southwest and East for the periods of 1970-2008. The results of this study proved that NSRP Model is able to imitate the pattern of actual rainfall in Peninsular Malaysia by comparing the parameters as well as the spatial distribution of the means and probabilities of 1 and 24 h rain. Thus, results from the NSRP model fitting for each station are valid to be used in further analysis that is to evaluate the behavior of storm rainfall. Moreover, almost all areas in Peninsula experienced the same probability of rain an hour between 0.03 and 0.09 also the probability of rain 24 h significantly increase on September with value between 0.41 and 0.69 during SWM season.

Key words: Storm rainfall, NSRP, geostatistical kriging, probability, agriculture, rectangular

INTRODUCTION

Nowadays, the issues of global warming and climatic change receive considerable attention from various researchers, particularly with regard to the effect of the behavior of the rain. The analysis of rainfall behavior is becoming important in many areas, particularly in water-related sectors such as agriculture, hydrology and water resource management. The expansion of irrigated agriculture, coupled with the development of industrialization and the rapid growth of population, contribute to the demand for the analysis of rainfall behaviour as such analysis can be utilized in rainfall forecasting and decision making. Studies on rainfall behavior have attracted much attention from scientists throughout the world such as those carried out by Lana *et al*. (2004), Martinez *et al*. (2007), Aravena and Luckman (2009), Roy (2009) and Turkes *et al*. (2008). In studying behaviors such as the intensity of rainfall, extreme rainfall, total rainfall and heavy rains have been studied using several statistical theories such as by using trends, (Frich *et al*., 2002; Brunetti *et al*., 2000, 2001; Piccarreta *et al*., 2004; Gong *et al*., 2004; Manton *et al*., 2001). A similar approach has been used by Zhang *et al*. (2009) to study the spatial distribution and trend of the rainfall concentration in the Pearl River basin, China. Their findings contributed to the basin-scale water resource management and conservation of the ecological environment. This method has also been applied to other regions such as India (Ananthakrishnan and Soman, 1989; Soman and Kumar, 1990) and Catalonia (Burgueno *et al*., 2004, 2005, 2010).

Research on rainfall behaviour, particularly examining the sequence of wet and dry days, had been explored

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successfully by a number of scientists. By Williams (1952) who was among the first to be involved in the study of the distribution of wet and dry sequences, suggested a Logarithmic Series Distribution (LSD) for data from England. He found that LSD fitted to the distribution of dry spells very well and many other researchers who have found success in this study (Theoharatos and Tselepidaki, 1990; Anagnostopoulou *et al*., 2003; Tolika and Maheras, 2005).

MATERIALS AND METHODS

Peninsular Malaysia is located in the tropics. It experiences a wet and humid tropical climate throughout the year, characterized by high annual rainfall, humidity and temperature. Peninsular Malaysia has a uniform temperature of 25.5°-32°C throughout the year. Generally, annual rainfall is between 2,000 and 4,000 mm while the annual number of wet days ranges from 150-200. The climate of Peninsular Malaysia is described by four monsoons or more precisely two monsoons separated by two inter-monsoons. In this study, the Southwest Monsoon (SWM) occurs from May to September. In Peninsular Malaysia, the Main Range Mountains, known locally as Banjaran Titiwangsa, run Southward from the Malaysia. Thai border in the North, spanning a distance of 483 km and separating the Eastern and Western parts of the Peninsula. During the NEM season, exposed areas in the Eastern part of the Peninsula receive heavy rainfall. In contrast areas sheltered by the main range, as shown in Fig. 1 are more or less free from its influence.

In this study, daily rainfall data from 50 rain gauge stations were obtained from the Malaysian Meteorological and Drainage and Irrigation Departments for the period of 1970-2008. Based on rainfall distribution, Dale (1959) delineated five rainfall regions in Peninsular Malaysia: Northwest, West, Port Dickson-Muar coast, Southwest and East (Tick and Samah, 2004). In this study, the stations located on the Port Dickson-Muar coast were combined with those in the Southwest region, due to the very limited number of stations available in the former. A list of the 50 stations is provided in Table 1.

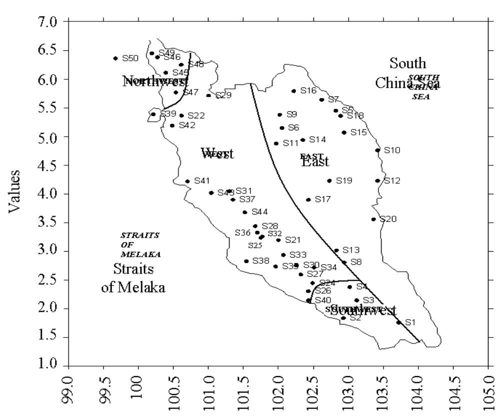

Fig. 1: The 50 rain gauge stations in Peninsular Malaysia

The single-site NSRP Model is characterized by a flexible structure in which the model parameters broadly relate to the underlying physical features observed in rainfall events. The NSRP model supposes that the storm origins follow a Poissonian process with parameter. Then, a random number of cell origins are displaced from the storm origins by exponentially distributed distances with parameter. A rectangular pulse with duration and intensity expressed by other two independent random variables, assumed to be exponentially distributed with

Table 1: The 50 rain gauges stations in Peninsular Malaysia with latitude and longitude

Code	Stations	State	Latitude	Longitude
S1	Kota Tinggi	Johor	1.76	103.72
S2	Batu Pahat	Johor	1.84	102.93
S3	Endau	Johor	2.65	103.62
S4	Labis	Johor	2.38	103.02
S5	Batu Hampar	Trengganu	5.45	102.82
S6	Bertam	Kelantan	5.15	102.05
S7	Besut	Trengganu	5.64	102.62
S8	Sg Chanis	Pahang	2.81	102.94
S9	Dabong	Kelantan	5.38	102.02
S10	Dungun	Trengganu	4.76	103.42
S11	Gua Musang	Kelantan	4.88	101.97
S12	Kemaman	Trengganu	4.23	103.42
S13	Sg Kepasing	Pahang	3.02	102.83
S14	Kg Aring	Kelantan	4.94	102.35
S15	Kg Dura	Trengganu	5.07	102.94
S16	Machang	Kelantan	5.79	102.22
S17	Paya Kangsar	Pahang	3.90	102.43
S18	Kg Sg Tong	Trengganu	5.36	102.89
S19	Ulu Tekai	Pahang	4.23	102.73
S20	Pekan	Pahang	3.56	103.36
S21	Ampang	Selangor	3.20	102.00
S22	Bkt Bendera	Pulau Pinang	5.42	100.27
S24	Chin Chin	Melaka	2.29	102.49
S25	Genting Klang	W.persekutuan	3.24	101.75
S26	jasin	Melaka	2.31	102.43
S28	Kalong Tengah	Selangor	3.44	101.67
S29	Kampar	Perak	5.71	101.00
S30	Kg Sawah Lebar	N.sembilan	2.76	102.26
S31	ladang bikam	Perak	4.05	101.30
S32	Kg Kuala Sleh	W.persekutuan	3.26	101.77
S33	Petaling	N.sembilan	2.94	102.07
S34	Rompin	N.sembilan	2.72	102.51
S35	Seremban	N.sembilan	2.74	101.96
S36	Sg Batu	W.persekutuan	3.33	101.70
S37	Sg Bernam	Selangor	3.70	101.35
S38	Sg Mangg	Selangor	2.83	101.54
S39	Sg Pinang	Pulau Pinang	5.39	100.21
S40	merlimau	Melaka	2.15	102.43
S41	Siti Awan	Perak	4.22	100.70
S42	Sg Sp Ampat	Pulau Pinang	5.29	100.48
S43	Telok Intan	Perak	4.02	101.04
S44	Tanjung Malim	Perak	3.68	101.52
S45	Alor Setar	Kedah	6.11	100.39
S46	Arau	Perlis	6.43	100.27
S47	Baling	Kedah	5.58	100.74
S48	Kuala Nerang	Kedah	6.25	100.61
S49	Padang Katong	Perlis	6.45	100.19
S50	Pdg Mat Sirat	Kedah	6.36	99.67

parameters and respectively, is associated at each cell origin. The total intensity at any point in time is given by the sum of all the active cell intensities at that particular point. The NSRP Model, therefore has a total of five parameters that can be estimated by minimizing an objective function, evaluated as sum of normalized residuals between the statistical properties of the observed and their theoretical expressions (Cowpertwait, 1991; Cowpertwait *et al.*,1996). The main feature of the model is its ability to preserve the statistical.

NSRP modeling initially uses these following conditions as follows: Every storm arrival, represented by l_i, i = 1, 2, 3, … is exponentially distributed in poisson process with parameter λ, Every rain cells, c_{ij}, i = storm index of i, j = rain cell index of storm-i, has poisson or geometry distribution with mean of E (C), Every waiting time for cells after the storm origin, b_{ik}, i = index storm of i, k = time of rain cell at storm-i will be exponentially distributed with mean β. In every rain cell, there are two other parameters forming cluster as rain cell intensity x_{jh}, j = jth cell, h = intensity at j th 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.

RESULTS AND DISCUSSION

Table 2 shows contain the estimated parameters of the NSRP Model for the 50 stations in the November and December. Rainfall data is generated based on the NSRP Model with parameters identified for each station and several statistics values in particular, the mean and probability values of the 1 and 24 h rainfall amount are then calculated. These statistics are chosen for their ability to describe the condition of a data set. To check on how well the NSRP Model obtained able to represent the actual rainfall data, the mean of the 1 h rainfall and the probabilities of the 1 and 24 h rainfall estimated from the model are compared with these statistics values calculated from the observed data. Part of the results, focusing on the month of November and December only is presented in Table 3. It can be seen that there are no major differences between the estimated and the observed values of the statistics of interest.

Results of statistical is compared with the statistical observation. For this purpose Table 3 is presented and it appears that the estimated are not significantly different from observed. Whereas the statistical probability of rain 24 h observed and estimated found slightly different results, the results can be found at station S1, S6 and S12. However, overall NSRP model conducted in Peninsular Malaysia has been successfully done.

Moreover, using a method of the Kriging, especially, on statistical spatial distibution will be carried out in Peninsular Malaysia, based on the Southwest Monsoon (SWM). Two important statistics namely mean and probability rain for 1 and 24 h will be use to produce the spatial distibution. The similarity spatial distibution the statistics observed and estimated is very important to quarante the NSRP Model have been success in Peninsular Malaysia.

Table 2: NSRP parameter for the 50 rain gauges stations

	November					December				
Stations	λ	β	η	E (C)	E (X)	λ	β	η	E (C)	E (X)
S1	0.025	0.116	2.23	2.56	93.70	0.012	0.078	1.48	7.88	56.82
S2	0.028	0.020	2.08	1.46	221.46	0.021	0.109	2.56	4.58	70.67
S3	0.033	0.221	2.22	1.39	15.58	0.012	0.081	2.16	5.70	5.96
S4	0.003	0.001	1.48	16.28	74.40	0.015	0.112	1.96	5.41	85.30
S5	0.012	0.068	3.03	4.34	12.69	0.021	0.197	3.08	3.22	11.94
S6	0.022	0.098	2.23	5.77	5.28	0.012	0.081	2.13	15.23	4.31
S7	0.012	0.034	1.50	13.68	8.65	0.009	0.026	1.03	22.14	4.93
S8	0.027	0.193	2.31	2.80	89.30	0.012	0.097	2.22	10.56	94.99
S9	0.017	0.062	1.64	7.69	6.24	0.011	0.061	1.60	16.08	5.39
S10	0.014	0.054	1.08	11.08	5.17	0.010	0.045	0.71	14.21	3.86
S11	0.026	0.088	2.12	3.81	7.87	0.010	0.055	1.56	10.91	4.75
S12	0.013	0.071	1.42	14.20	56.95	0.010	0.060	1.32	36.41	35.41
S13	0.029	0.132	2.31	2.67	95.27	0.012	0.054	1.67	7.45	69.41
S14	0.022	0.050	1.92	5.49	7.24	0.012	0.066	1.83	17.26	6.23
S15	0.021	0.047	1.91	8.95	8.16	0.013	0.040	1.24	20.43	4.99
S16	0.015	0.095	1.72	14.23	4.71	0.008	0.097	3.23	94.52	3.65
S17	0.020	0.066	1.98	3.75	7.41	0.014	0.053	1.68	6.69	5.27
S18	0.020	0.054	1.77	9.27	8.06	0.013	0.034	1.01	13.76	7.87
S19	0.023	0.126	3.31	5.63	13.26	0.012	0.111	4.95	44.97	6.26
S20	0.025	0.083	1.54	3.54	8.36	0.011	0.055	0.96	10.71	6.09
S21	0.007	0.037	2.30	10.95	5.67	0.008	0.096	2.82	5.65	7.62
S22	0.027	0.074	1.74	2.83	8.64	0.012	0.067	1.97	2.90	8.83
S24	0.028	0.478	3.02	11.38	2.71	0.012	0.081	2.16	5.70	5.96
S25	0.037	0.121	2.08	2.57	82.69	0.009	0.042	2.03	6.55	85.79
S26	0.031	0.786	4.92	7.30	6.28	0.009	0.076	2.62	10.32	5.15
S28	0.051	0.177	1.95	2.44	6.69	0.016	0.059	1.86	5.05	5.90

Table 2: Countinue

	November					December				
Stations	λ	β	η	E (C)	E (X)	λ	β	η	E (C)	E (X)
S29	0.038	0.089	2.13	2.51	10.65	0.026	0.076	1.94	2.48	11.14
S30	0.015	0.044	2.15	4.67	79.97	0.014	0.066	1.80	5.34	44.10
S31	0.032	0.085	2.18	3.26	8.78	0.038	0.798	3.23	2.80	11.58
S32	0.048	0.263	2.52	1.95	110.72	0.015	0.051	2.63	3.47	107.19
S33	0.026	0.139	2.16	3.22	61.91	0.016	0.080	2.02	4.11	60.17
S34	0.023	0.080	2.17	4.92	60.32	0.014	0.061	1.69	6.91	44.12
S35	0.034	0.169	2.14	3.15	7.09	0.014	0.069	2.07	4.53	6.56
S36	0.038	0.051	2.48	2.35	129.97	0.033	0.170	2.46	2.42	97.96
S37	0.036	0.186	2.74	3.46	8.51	0.020	0.091	2.83	3.78	11.08
S38	0.037	0.658	3.49	4.47	63.64	0.024	0.198	3.71	3.78	97.53
S39	0.030	0.281	2.07	3.57	7.27	0.010	0.103	1.82	3.98	6.87
S40	0.024	0.141	4.31	4.98	8.45	0.011	0.102	2.36	6.61	4.97
S41	0.031	0.236	2.05	2.55	6.56	0.017	0.092	2.31	3.86	8.57
S42	0.028	0.100	1.65	3.20	6.78	0.016	0.122	1.79	3.19	6.77
S43	0.033	0.186	2.19	3.38	7.64	0.024	0.181	2.01	3.10	8.67
S44	0.037	0.110	2.22	3.31	7.94	0.022	0.086	2.43	3.12	8.86
S45	0.007	0.113	2.05	16.27	2.09	0.007	0.086	2.58	7.40	5.46
S46	0.010	0.054	2.61	16.49	5.70	0.005	0.067	3.98	24.89	8.23
S47	0.012	0.127	2.39	5.97	5.04	0.006	0.097	3.34	5.57	9.60
S48	0.022	0.147	1.89	5.16	4.11	0.008	0.080	1.51	6.92	3.62
S49	0.078	0.179	2.57	1.01	67.53	0.003	0.048	1.09	22.20	16.50
S50	0.011	0.061	2.43	8.10	6.89	0.008	0.098	2.86	4.09	7.68

Table 3 Comparison statistics estimated and observed for 50 rain gauges stations

	November						December					
Stations	ME	MO	KE	KO	KE2	KO2	ME	MO	KE	KO	KE2	KO2
S1	2.72	2.74	0.08	0.08	0.57	0.57	3.54	3.31	0.12	0.11	0.47	0.51
S2	4.38	3.45	0.06	0.11	0.61	0.64	2.67	2.73	0.11	0.11	0.58	0.56
S3	0.32	0.29	0.06	0.10	0.58	0.58	0.19	0.19	0.08	0.08	0.45	0.44
S4	2.58	2.61	0.08	0.09	0.69	0.55	3.52	2.80	0.10	0.11	0.47	0.49
S5	0.22	0.23	0.06	0.06	0.44	0.42	0.26	0.27	0.07	0.08	0.49	0.47
S6	0.30	0.29	0.14	0.14	0.63	0.66	0.36	0.32	0.17	0.16	0.52	0.60
S7	0.93	0.89	0.20	0.20	0.69	0.70	0.98	0.96	0.27	0.27	0.72	0.72
S8	2.96	2.91	0.09	0.09	0.57	0.58	5.62	4.23	0.13	0.13	0.48	0.58
S9	0.50	0.47	0.16	0.16	0.64	0.69	0.61	0.54	0.19	0.18	0.57	0.66
S10	0.76	0.70	0.21	0.21	0.65	0.73	0.76	0.71	0.22	0.21	0.58	0.64
S11	0.37	0.36	0.12	0.12	0.66	0.68	0.34	0.32	0.14	0.14	0.52	0.56
S12	7.66	6.68	0.20	0.20	0.59	0.70	9.42	8.31	0.27	0.26	0.58	0.68
S13	3.25	3.18	0.10	0.10	0.62	0.65	3.60	3.43	0.11	0.11	0.53	0.56
S14	0.45	0.45	0.15	0.15	0.73	0.73	0.69	0.58	0.20	0.19	0.57	0.69
S15	0.80	0.78	0.22	0.22	0.78	0.79	1.04	1.00	0.29	0.29	0.73	0.73
S16	0.58	0.53	0.20	0.19	0.57	0.65	0.88	0.74	0.23	0.22	0.46	0.57
S17	0.28	0.28	0.10	0.10	0.60	0.60	0.29	0.30	0.12	0.12	0.58	0.57
S18	0.83	0.80	0.21	0.21	0.74	0.75	1.45	0.97	0.26	0.25	0.74	0.75
S19	0.52	0.40	0.13	0.14	0.61	0.71	0.69	0.48	0.23	0.20	0.53	0.64
S20	0.48	0.47	0.12	0.12	0.64	0.64	0.76	0.70	0.17	0.17	0.55	0.61
S21	0.18	0.18	0.09	0.09	0.45	0.46	0.13	0.12	0.05	0.05	0.32	0.33
S22	0.38	0.38	0.11	0.11	0.66	0.65	0.16	0.16	0.05	0.05	0.39	0.39
S24	0.29	0.29	0.15	0.10	0.57	0.58	0.19	0.19	0.08	0.08	0.45	0.44
S25	3.74	3.80	0.12	0.12	0.71	0.68	2.45	2.37	0.08	0.08	0.46	0.48
S26	0.29	0.28	0.11	0.12	0.57	0.56	0.18	0.17	0.09	0.09	0.40	0.41
S28	0.43	0.43	0.15	0.16	0.79	0.75	0.26	0.27	0.11	0.11	0.58	0.55
S29	0.48	0.49	0.12	0.13	0.74	0.70	0.37	0.37	0.09	0.09	0.61	0.60
S30	2.63	2.70	0.09	0.09	0.58	0.56	1.79	1.81	0.10	0.10	0.51	0.51
S31	0.43	0.44	0.13	0.13	0.73	0.68	0.38	0.36	0.09	0.12	0.63	0.63
S32	4.13	4.14	0.11	0.11	0.73	0.73	2.13	2.16	0.07	0.07	0.52	0.51
S33	2.40	2.42	0.10	0.10	0.59	0.59	1.94	1.97	0.08	0.08	0.50	0.49
S34	3.17	3.21	0.14	0.14	0.66	0.65	2.45	2.43	0.12	0.12	0.55	0.56
S35	0.35	0.36	0.13	0.13	0.67	0.64	0.21	0.21	0.08	0.08	0.50	0.48
S36	4.64	4.67	0.11	0.11	0.78	0.77	3.15	3.15	0.10	0.10	0.63	0.63
S37	0.39	0.40	0.13	0.14	0.69	0.67	0.29	0.30	0.09	0.09	0.56	0.54
S38	2.98	2.99	0.11	0.11	0.63	0.63	2.42	2.47	0.09	0.09	0.55	0.53
S39	0.37	0.37	0.11	0.11	0.59	0.60	0.16	0.15	0.05	0.05	0.34	0.35
S40	0.23	0.24	0.11	0.12	0.59	0.56	0.16	0.16	0.08	0.08	0.41	0.40
S41	0.26	0.26	0.10	0.10	0.60	0.59	0.24	0.24	0.08	0.08	0.49	0.50
S42	0.37	0.37	0.12	0.12	0.66	0.65	0.20	0.20	0.07	0.07	0.44	0.43
S43	0.39	0.40	0.13	0.13	0.65	0.63	0.32	0.32	0.09	0.09	0.53	0.53

Table 3: Continue

	November						December					
Stations	ME	MO	KE	KO	KE2	KO2	ME	MO	KE	KO	KE2	KO2
S44	0.44	0.45	0.15	0.15	0.74	0.71	0.25	0.26	0.09	0.09	0.58	0.57
S45	0.11	0.11	0.09	0.09	0.29	0.28	0.11	0.12	0.06	0.06	0.30	0.29
S46	0.38	0.37	0.17	0.17	0.57	0.57	0.28	0.23	0.10	0.10	0.34	0.40
S47	0.15	0.15	0.08	0.08	0.38	0.38	0.10	0.10	0.04	0.04	0.25	0.25
S48	0.25	0.25	0.13	0.13	0.57	0.58	0.13	0.13	0.07	0.07	0.35	0.36
S49	2.08	2.45	0.10	0.10	0.85	0.51	0.90	0.96	0.07	0.07	0.22	0.21
S50	0.25	0.25	0.10	0.10	0.50	0.50	0.09	0.09	0.04	0.04	0.29	0.29

ME = Mean of 1 h rainfall, MO = Mean of 1 h rainfall, KE = Probability of 1 h rainfall, KO = Probability of 1 h rainfall, KE2 = Probability of 24 h rainfall, KO2 = Probability of 24 h rainfall

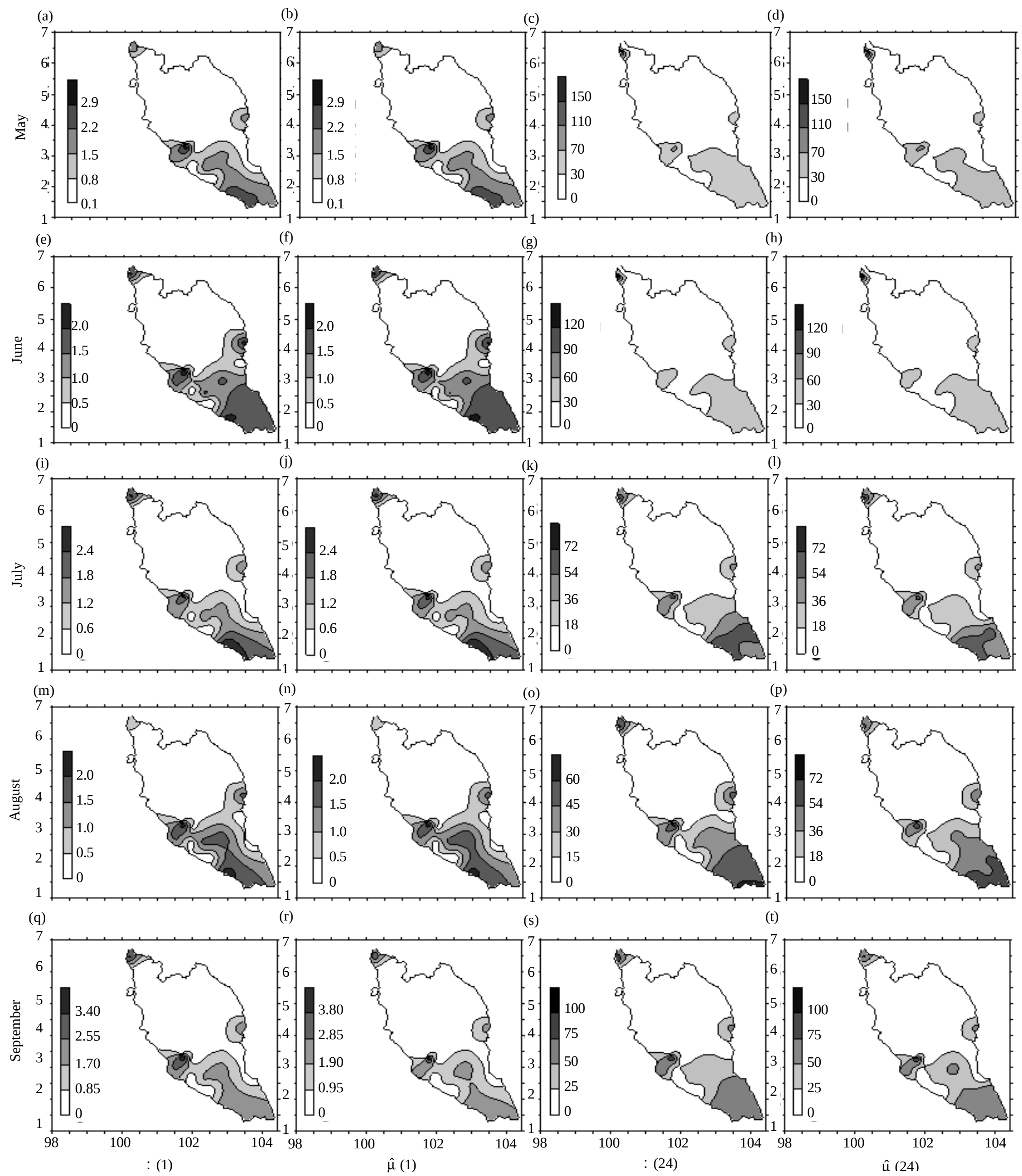

Fig. 2: a-t) Mean of rain an 1, 24 h observed μ (1), μ (24) and estimated $\hat{\mu}(1)$, $\hat{\mu}(24)$ during SWM

Figure 2 can be seen that the spatial distibution of the statistical mean 1 and 24 h rainfall estimates not dissimilar to the statistical observations, especially for the months of June through September. From these results can be found that modeling NSRP has successfully carried out during SWM. To strengthen this result the spatial distibution statistics probability of rain 1 and 24 h of observed and estimated were produced form, Fig. 3 has been found also that the spatial distibution of the observed and estimated statistics for the months during SWM not significantly different. From this result has strengthened back that NSRP modeling has successfully done in Peninsular Malaysia, especially in May, June, August and September during the SWM.

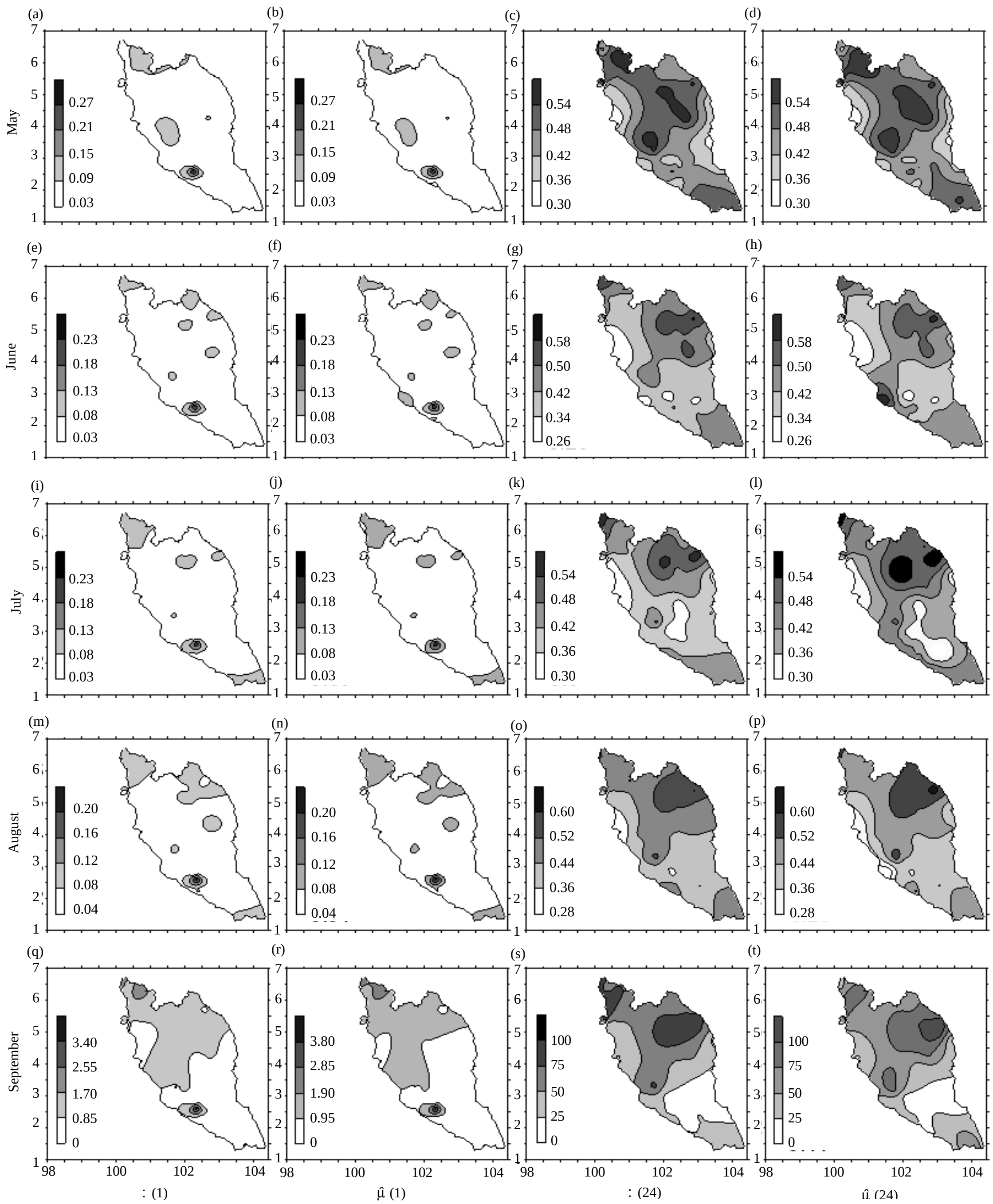

Fig. 3: Probability of rain 1, 24 h observed μ (1), μ (24) and estimated $\hat{\mu}(1)$, $\hat{\mu}(24)$ during SWM

Figure 2 depicts the spatial distribution mean of rain an hour for SWM season recorded during the period 1970-2008. Form this spatial distibution found that almost all area of the Southwest region has an higher mean of rain 1 h than other areas in Peninsula was recorded more than 1.5 mm. A few small and isolated areas in West region which were found to have the largest mean of rain 1 h during SWM season and during this season the lowest this statistics of <0.5 mm was observed in the West and East regions, particularly on June and August. While the most of larger the mean of rain 24 h seen during the SWM season was recorded along Southwest region with value over 50 mm. However, a few and isolated areas in the West region which were found to have the largest mean of rain 24 h during SWM season with value over 70 mm, particularly on July.

In term of probability of rain an hour it can be concluded that almost all areas in Peninsula experienced the same probability of rain an hour between 0.03 and 0.09 during SWM season as shown in Fig. 3.

Referring to Fig. 3, only a few places in the West region, recorded more 0.20 during SWM season. During this season, particularly on September the probability rain an hour increasing almost all areas in Northwest region with value between 0.09 and 0.19. In this season a few areas on Northwest region particularly on May the probability of rain an hour with value between 0.09 and 0.15 was observed. Small parts of the East region also received with value between 0.08 and 0.13 during SWM season particularly on June. The similar value also was found on Southwest region, particularly on July and August. While the largest probability rain 24 h identified in several areas including the East and Northwest, ranging 0.5 and 0.69 during SWM season. The lowest probability rain 24 h was observed in a few areas in the West region with value between 0.26 and 0.36 during SWM season while in this season particularly on September the lowest probability of rain 24 h was observed in few areas at East and Southwest regions with value between 0.41 and 0.48.

CONCLUSION

This study, overall NSRP Model in Peninsular Malaysia has been successfully done. Hourly rainfall data for the periods of 1970-2008 from 50 rain-gauge stations in Peninsular Malaysia is used in this study. The rain-gauge stations are divided into four sub-regions, namely Northwest, West, Southwest and East. The goodness of fit of the NSRP Model to the observation is tested first before further application of the model. The results showed the NSRP Model is able to represent the rainfall data in Peninsular Malaysia. During SWM season the probability of rain 24 h significantly increase on September with value between 0.41 and 0.69. In term of probability of rain an hour it can be concluded that almost all areas in Peninsula experienced the same probability of rain an hour between 0.03 and 0.09 during SWM season.

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