Journal of Engineering and Applied Sciences 12 (24): 7640-7648, 2017
ISSN: 1816-949X

Long-Term Daily Rainfall Pattern in Peninsular Malaysia

[1]Rado Yendra, [2]Anofrizen, [3]Wan Zawiah Wan Zin, [3]Abdul Aziz Jemain and [4]Ahmad Fudholi
[1]Department of Mathematics,
[2]Department of System Information, Faculty of Science and Technology,
Universitas Islam Negeri Sultan Syarif Kasim (UIN Suska), 28293 Pekanbaru, Riau, Indonesia
[3]School of Mathematical Sciences, Faculty of Science and Technology,
[4]Solar Energy Research Institute, Universiti Kebangsaan Malaysia (UKM), 43600 Bangi,
Selangor, Malaysia

Abstract: This study aims to investigate the daily rainfall pattern over a 39 year period (1970-2008) using data from 50 selected rainfall stations. The trends and spatial pattern of the daily rainfall data in Peninsular Malaysia based on seasonal rainfall indices. The storm behaviors comprising of the Arrivals Storm (AS), the Number of Raincells (NR), the Raincells Intensity (RI) and the Raincells Duration (RD) will be used to analyze during the monsoon seasons. Due to the limited number of stations, the geostatistical method of ordinary kriging is used to compute the values of properties of storm and to map their spatial distribution. The findings of this study indicate that there were differences in spatial distribution of arrival storm over Peninsula during both seasons with highest rate arrival storm over the East compared to other regions during South West Monsoon (SWM). In contrast, the rate arrival storm significantly decreasing over the East regions during North East Monsoon (NEM). The storm is more common in NEM season than SWM season. In terms of number of raincells, it can be concluded that the spatial distribution rate number of raincells during NEM season higher than SWM season. In contrast, the spatial distribution the rate raincells intensity during NEM seasons lower than SWM season. However, no significant differences in raincells duration during both seasons over Peninsula. This finding explains the occurrence of a large number of floods and soil erosions would more likely occur in the NEM, especially in the South West and East region. Therefore, precautionary measures should be taken earlier to prevent any massive destruction of property and loss of life due to the hazards.

Key words: Storm rainfall, NSRP, Geostatistical Kriging, spatial, distribution, erosion

INTRODUCTION

Climate change is an undeniable, pervasive and insidious world crisis with prominent increases in the intensity and frequency of many extreme events such as tropical cyclones, heat waves, thunderstorms, prolonged dry spells, tornadoes, intense rainfall and severe dust storms in some regions (Othman *et al*., 2015). The issues of climatic change receive considerable attention from various scientist, 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 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 (Khalid *et al*., 2016; Shakib *et al*., 2016).

Generally, Peninsular Malaysia is formed of highland, floodplain and coastal zones. The Titiwangsa Range forms the backbone of the Peninsula which runs from the Malaysia-Thailand border in the North to the South over a distance of 483 km and separates the Eastern part from the Western (Suhaila and Jemain, 2007). The climate of the Peninsula is very much influenced by two main monsoons: the South West Monsoon (SWM) from May to August and the North East Monsoon (NEM) from November to February (Suhaila and Jemain, 2009a, b). There have been a few published works on the behavior rainfall Peninsular Malaysia. Among them are works on detecting trends in dry and wet spells over the Peninsula during monsoon seasons (Deni *et al*., 2008, 2010a, b), changes in extreme rainfall events (Wan *et al*., 2010), changes in daily rainfall during monsoon seasons (Suhaila *et al*., 2010) and analysis of rainfall variability (Wong *et al*., 2009).

The rainfall behavior have been studied by scientists (Aravena and Luckman, 2009; Turkes *et al*., 2008;

Corresponding Author: Rado Yendra, Department of Mathematics, Faculty of Science and Technology,
Universitas Islam Negeri Sultan Syarif Kasim (UIN Suska), 28293 Pekanbaru, Riau, Indonesia

Martinez *et al*., 2007; Lana *et al*., 2004). In studying behaviors such as the extreme rainfall, intensity of rainfall, total rainfall and heavy rains have been studied using statistical theories (Gong *et al*., 2004; Piccarreta *et al*., 2004; Frich *et al*., 2002; Manton *et al*., 2001; Brunetti *et al*., 2001; Tick and Samah, 2004). The trend and spatial distribution of the rainfall concentration in China have studied by Zhang *et al*. (2009). They 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 Catalonia (Burgueno *et al*., 2004, 2005, 2010) and India (Soman and Kumar, 1990; Ananthakrishnan and Soman, 1989).

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 whille 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 South West 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: North West, West, Port Dickson-Muar coast, South West and East (Brunetti *et al*., 2000). In this study, the stations located on the Port Dickson-Muar coast were combined with those in the South West region, due to the very limited number of stations available in the former. A list of the 50 stations is provided in Table 1.

There are two models that can be used to analyze the rainfall data at a scale of hours or minutes, first, we consider models for a single site (Rodriguez-Iturbe *et al*., 1987; Favre *et al*., 2004) in which storms arrive randomly according to a poisson process, each storm consisting of

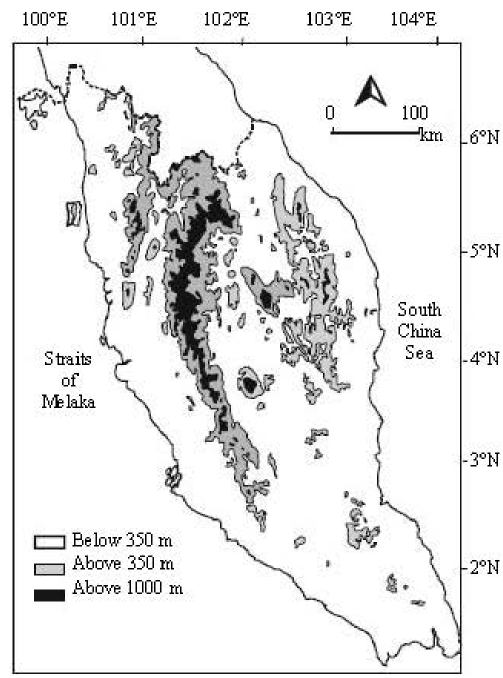

Fig. 1: Physical map of Peninsular Malaysia

a random number of cells, each depositing rain for a random period. The arrivals of cells form a stochastic series of points in time subject to clustering. Two models have been used in the literature to represent such a clustered point process. Both models involve 5/6 storm behaviour (parameters), depending on the assumptions used.

In general, the parameters of the NSRP Model can be estimated by selecting a set that matches as closely as possible, the expected statistics of the generated time series with the corresponding statistics estimated from observed rainfall time series. To implement this, the model parameters are estimated by minimizing:

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

Where:

- k = The set of statistics
- τ = The each with a specified aggregation level
- $\Theta_k(X, \tau)$ = The expected value of k for the NSRP Model using a given set of parameters
- Θ_k^{*} = The sample estimate of k evaluated from observed data

A numerical optimizing routine such as the Simplex algorithm is used to find the parameter set that minimizes the Z(X) function subject to fixed upper and lower bounds applied to the parameters (Yendra *et al*., 2015, 2017).

Table 1: The 50 rain gauges stations in Peninsular Malaysia

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

The NSRP Model therefore has a total of 5 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 (Rodriguez-Iturbe *et al*., 1987; Cowpertwait, 1991; Cowpertwait *et al*., 1996).

RESULTS AND DISCUSSION

The following sections discuss the application of the NSRP Model to produces parameter based on hourly rainfall data of 50 rain gauges stations used in this study. In Table 2 has displayed NSRP parameters for the precipitation on November and December. Parameters that have been produced the next will be tested ability to estimate some statistics that are considered important such as mean of rain an hour, probability of rain 1 and 24 h.

Results of statistical is compared with the statistical observation. For this purpose, Table 3 are 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.

Figure 2 and 3 depict the spatial distribution of rainfall behaviour for SWM and NEM, recorded during the period 1970-2008. The largest rate of AR during the SWM season was seen over the Eastern region, particularly on July. During this month the storm arrival rates of >0.042 or in other words, on average, exceed 0.99 storm occurred today. While this season is also the Western region is the lowest with storm arrival rates of not more than 0.002 in other words storm occurred not more than 20.83 days. The storm arrival rate of increase in NEM season especially on November, in this month storm arrival rate of >0.06 or storm took place about the time of 0.69 days whille the lowest rate of storm arrival occurs in East region with the not more than 0.002 storm occurred not more than 20.83 days. From these results, it appears that storm more often during the NEM season, especially in the West and SouthWest.

The spatial distribution of Raincell Intensity (RI) during the SWM and NEM seasons can be found on Fig. 2 and 3. RI of more than 340 mm/h was observed over the Peninsula during the SWM season on September with the largest RI identified in several areas including the South Western Peninsula. The lowest RI was observed in the Eastern and Western regions. During the NEM season, the South Western region recorded the highest RI with more than 200 mm/h was observed, particularly on November. While, the lowest can be found in a few areas on North West region with value not more than 55 mm/h. This findings can explain that during NEM season RI lower than SWM season.

The spatial distribution of Number of Raincell (NR) values during both seasons is displayed in Fig. 2 and 3. The largest NR during the SWM season was observed mainly in the South Western Peninsula recorded more than 42 mm, particularly on September. During the SWM season, most areas recorded not more 8. While during the NEM season, it can be concluded that almost all areas in

Table 2: NSRP parameter of 50 rain gauges stations

	November					December				
Regions/Stations	λ	E(X)	E(C)	β	η	λ	E(X)	E(C)	β	η
South West										
S1	0.025	93.70	2.56	0.116	2.23	0.012	56.82	7.88	0.078	1.48
S2	0.028	221.46	1.46	0.020	2.08	0.021	70.67	4.58	0.109	2.56
S3	0.033	15.58	1.39	0.221	2.22	0.012	5.96	5.70	0.081	2.16
S4	0.003	74.40	16.28	0.001	1.48	0.015	85.30	5.41	0.112	1.96
East										
S5	0.012	12.69	4.34	0.068	3.03	0.021	11.94	3.22	0.197	3.08
S6	0.022	5.28	5.77	0.098	2.23	0.012	4.31	15.23	0.081	2.13
S7	0.012	8.65	13.68	0.034	1.50	0.009	4.93	22.14	0.026	1.03
S8	0.027	89.30	2.80	0.193	2.31	0.012	94.99	10.56	0.097	2.22
S9	0.017	6.24	7.69	0.062	1.64	0.011	5.39	16.08	0.061	1.60
S10	0.014	5.17	11.08	0.054	1.08	0.010	3.86	14.21	0.045	0.71
S11	0.026	7.87	3.81	0.088	2.12	0.010	4.75	10.91	0.055	1.56
S12	0.013	56.95	14.20	0.071	1.42	0.010	35.41	36.41	0.060	1.32
S13	0.029	95.27	2.67	0.132	2.31	0.012	69.41	7.45	0.054	1.67
S14	0.022	7.24	5.49	0.050	1.92	0.012	6.23	17.26	0.066	1.83
S15	0.021	8.16	8.95	0.047	1.91	0.013	4.99	20.43	0.040	1.24
S16	0.015	4.71	14.23	0.095	1.72	0.008	3.65	94.52	0.097	3.23
S17	0.020	7.41	3.75	0.066	1.98	0.014	5.27	6.69	0.053	1.68
S18	0.020	8.06	9.27	0.054	1.77	0.013	7.87	13.76	0.034	1.01
S19	0.023	13.26	5.63	0.126	3.31	0.012	6.26	44.97	0.111	4.95
S20	0.025	8.36	3.54	0.083	1.54	0.011	6.09	10.71	0.055	0.96
West										
S21	0.007	5.67	10.95	0.037	2.30	0.008	7.62	5.65	0.096	2.82
S22	0.027	8.64	2.83	0.074	1.74	0.012	8.83	2.90	0.067	1.97
S24	0.028	2.71	11.38	0.478	3.02	0.012	5.96	5.70	0.081	2.16
S25	0.037	82.69	2.57	0.121	2.08	0.009	85.79	6.55	0.042	2.03
S26	0.031	6.28	7.30	0.786	4.92	0.009	5.15	10.32	0.076	2.62
S28	0.051	6.69	2.44	0.177	1.95	0.016	5.90	5.05	0.059	1.86
S29	0.038	10.65	2.51	0.089	2.13	0.026	11.14	2.48	0.076	1.94
S30	0.015	79.97	4.67	0.044	2.15	0.014	44.10	5.34	0.066	1.80
S31	0.032	8.78	3.26	0.085	2.18	0.038	11.58	2.80	0.798	3.23
S32	0.048	110.72	1.95	0.263	2.52	0.015	107.19	3.47	0.051	2.63
S33	0.026	61.91	3.22	0.139	2.16	0.016	60.17	4.11	0.080	2.02
S34	0.023	60.32	4.92	0.080	2.17	0.014	44.12	6.91	0.061	1.69
S35	0.034	7.09	3.15	0.169	2.14	0.014	6.56	4.53	0.069	2.07
S36	0.038	129.97	2.35	0.051	2.48	0.033	97.96	2.42	0.170	2.46
S37	0.036	8.51	3.46	0.186	2.74	0.020	11.08	3.78	0.091	2.83
S38	0.037	63.64	4.47	0.658	3.49	0.024	97.53	3.78	0.198	3.71
S39	0.030	7.27	3.57	0.281	2.07	0.010	6.87	3.98	0.103	1.82
S40	0.024	8.45	4.98	0.141	4.31	0.011	4.97	6.61	0.102	2.36
S41	0.031	6.56	2.55	0.236	2.05	0.017	8.57	3.86	0.092	2.31
S42	0.028	6.78	3.20	0.100	1.65	0.016	6.77	3.19	0.122	1.79
S43	0.033	7.64	3.38	0.186	2.19	0.024	8.67	3.10	0.181	2.01
S44	0.037	7.94	3.31	0.110	2.22	0.022	8.86	3.12	0.086	2.43
North West										
S45	0.007	2.09	16.27	0.113	2.05	0.007	5.46	7.40	0.086	2.58
S46	0.010	5.70	16.49	0.054	2.61	0.005	8.23	24.89	0.067	3.98
S47	0.012	5.04	5.97	0.127	2.39	0.006	9.60	5.57	0.097	3.34
S48	0.022	4.11	5.16	0.147	1.89	0.008	3.62	6.92	0.080	1.51
S49	0.078	67.53	1.01	0.179	2.57	0.003	16.50	22.20	0.048	1.09
S50	0.011	6.89	8.10	0.061	2.43	0.008	7.68	4.09	0.098	2.86

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

	November						December					
Stations	MO	ME	KO	KE	KO2	KE2	MO	ME	KO	KE	KO2	KE2
S1	2.74	2.72	0.08	0.08	0.57	0.57	3.31	3.54	0.11	0.12	0.51	0.47
S2	3.45	4.38	0.11	0.06	0.64	0.61	2.73	2.67	0.11	0.11	0.56	0.58
S3	0.29	0.32	0.10	0.06	0.58	0.58	0.19	0.19	0.08	0.08	0.44	0.45
S4	2.61	2.58	0.09	0.08	0.55	0.69	2.80	3.52	0.11	0.10	0.49	0.47
S5	0.23	0.22	0.06	0.06	0.42	0.44	0.27	0.26	0.08	0.07	0.47	0.49
S6	0.29	0.30	0.14	0.14	0.66	0.63	0.32	0.36	0.16	0.17	0.60	0.52
S7	0.89	0.93	0.20	0.20	0.70	0.69	0.96	0.98	0.27	0.27	0.72	0.72
S8	2.91	2.96	0.09	0.09	0.58	0.57	4.23	5.62	0.13	0.13	0.58	0.48

Table 3: Continue

	November						December					
Stations	MO	ME	KO	KE	KO2	KE2	MO	ME	KO	KE	KO2	KE2
S9	0.47	0.50	0.16	0.16	0.69	0.64	0.54	0.61	0.18	0.19	0.66	0.57
S10	0.70	0.76	0.21	0.21	0.73	0.65	0.71	0.76	0.21	0.22	0.64	0.58
S11	0.36	0.37	0.12	0.12	0.68	0.66	0.32	0.34	0.14	0.14	0.56	0.52
S12	6.68	7.66	0.20	0.20	0.70	0.59	8.31	9.42	0.26	0.27	0.68	0.58
S13	3.18	3.25	0.10	0.10	0.65	0.62	3.43	3.60	0.11	0.11	0.56	0.53
S14	0.45	0.45	0.15	0.15	0.73	0.73	0.58	0.69	0.19	0.20	0.69	0.57
S15	0.78	0.80	0.22	0.22	0.79	0.78	1.00	1.04	0.29	0.29	0.73	0.73
S16	0.53	0.58	0.19	0.20	0.65	0.57	0.74	0.88	0.22	0.23	0.57	0.46
S17	0.28	0.28	0.10	0.10	0.60	0.60	0.30	0.29	0.12	0.12	0.57	0.58
S18	0.80	0.83	0.21	0.21	0.75	0.74	0.97	1.45	0.25	0.26	0.75	0.74
S19	0.40	0.52	0.14	0.13	0.71	0.61	0.48	0.69	0.20	0.23	0.64	0.53
S20	0.47	0.48	0.12	0.12	0.64	0.64	0.70	0.76	0.17	0.17	0.61	0.55
S21	0.18	0.18	0.09	0.09	0.46	0.45	0.12	0.13	0.05	0.05	0.33	0.32
S22	0.38	0.38	0.11	0.11	0.65	0.66	0.16	0.16	0.05	0.05	0.39	0.39
S24	0.29	0.29	0.10	0.15	0.58	0.57	0.19	0.19	0.08	0.08	0.44	0.45
S25	3.80	3.74	0.12	0.12	0.68	0.71	2.37	2.45	0.08	0.08	0.48	0.46
S26	0.28	0.29	0.12	0.11	0.56	0.57	0.17	0.18	0.09	0.09	0.41	0.40
S28	0.43	0.43	0.16	0.15	0.75	0.79	0.27	0.26	0.11	0.11	0.55	0.58
S29	0.49	0.48	0.13	0.12	0.70	0.74	0.37	0.37	0.09	0.09	0.60	0.61
S30	2.70	2.63	0.09	0.09	0.56	0.58	1.81	1.79	0.10	0.10	0.51	0.51
S31	0.44	0.43	0.13	0.13	0.68	0.73	0.36	0.38	0.12	0.09	0.63	0.63
S32	4.14	4.13	0.11	0.11	0.73	0.73	2.16	2.13	0.07	0.07	0.51	0.52
S33	2.42	2.40	0.10	0.10	0.59	0.59	1.97	1.94	0.08	0.08	0.49	0.50
S34	3.21	3.17	0.14	0.14	0.65	0.66	2.43	2.45	0.12	0.12	0.56	0.55
S35	0.36	0.35	0.13	0.13	0.64	0.67	0.21	0.21	0.08	0.08	0.48	0.50
S36	4.67	4.64	0.11	0.11	0.77	0.78	3.15	3.15	0.10	0.10	0.63	0.63
S37	0.40	0.39	0.14	0.13	0.67	0.69	0.30	0.29	0.09	0.09	0.54	0.56
S38	2.99	2.98	0.11	0.11	0.63	0.63	2.47	2.42	0.09	0.09	0.53	0.55
S39	0.37	0.37	0.11	0.11	0.60	0.59	0.15	0.16	0.05	0.05	0.35	0.34
S40	0.24	0.23	0.12	0.11	0.56	0.59	0.16	0.16	0.08	0.08	0.40	0.41
S41	0.26	0.26	0.10	0.10	0.59	0.60	0.24	0.24	0.08	0.08	0.50	0.49
S42	0.37	0.37	0.12	0.12	0.65	0.66	0.20	0.20	0.07	0.07	0.43	0.44
S43	0.40	0.39	0.13	0.13	0.63	0.65	0.32	0.32	0.09	0.09	0.53	0.53
S44	0.45	0.44	0.15	0.15	0.71	0.74	0.26	0.25	0.09	0.09	0.57	0.58
S45	0.11	0.11	0.09	0.09	0.28	0.29	0.12	0.11	0.06	0.06	0.29	0.30
S46	0.37	0.38	0.17	0.17	0.57	0.57	0.23	0.28	0.10	0.10	0.40	0.34
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	0.58	0.57	0.13	0.13	0.07	0.07	0.36	0.35
S49	2.45	2.08	0.10	0.10	0.51	0.85	0.96	0.90	0.07	0.07	0.21	0.22
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 and KO2 = Probability of 24 h rainfall

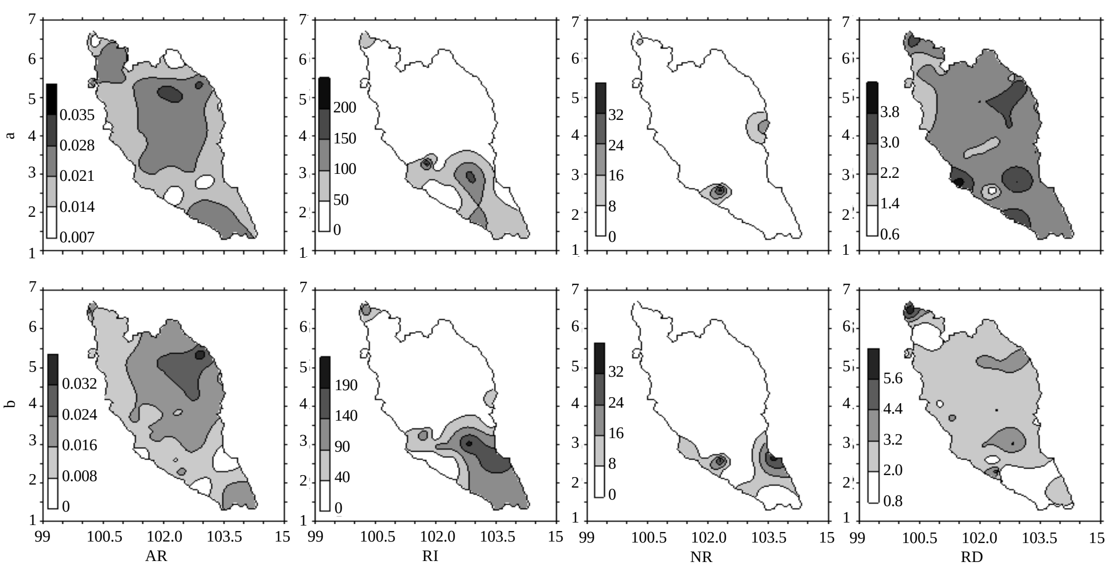

Fig. 2: Continue

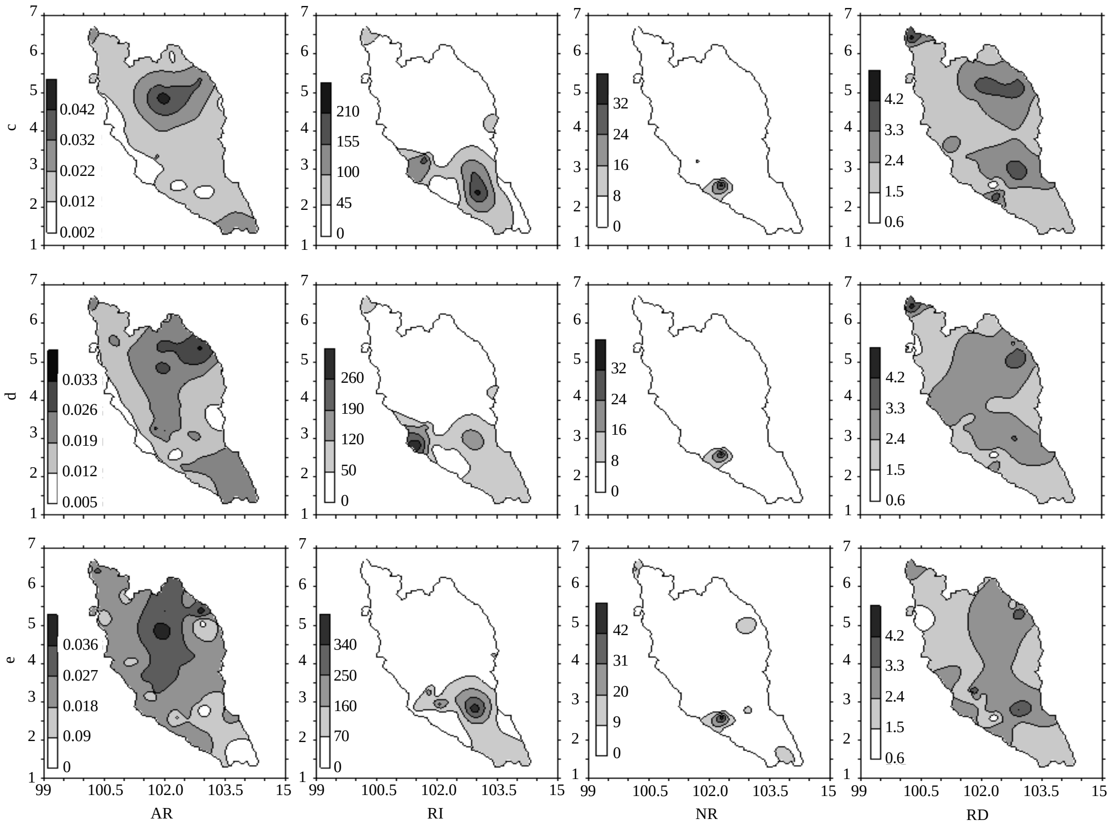

Fig. 2: NSRP Parameters during SWM: a) May; b) June; c) July; d) August and e) September

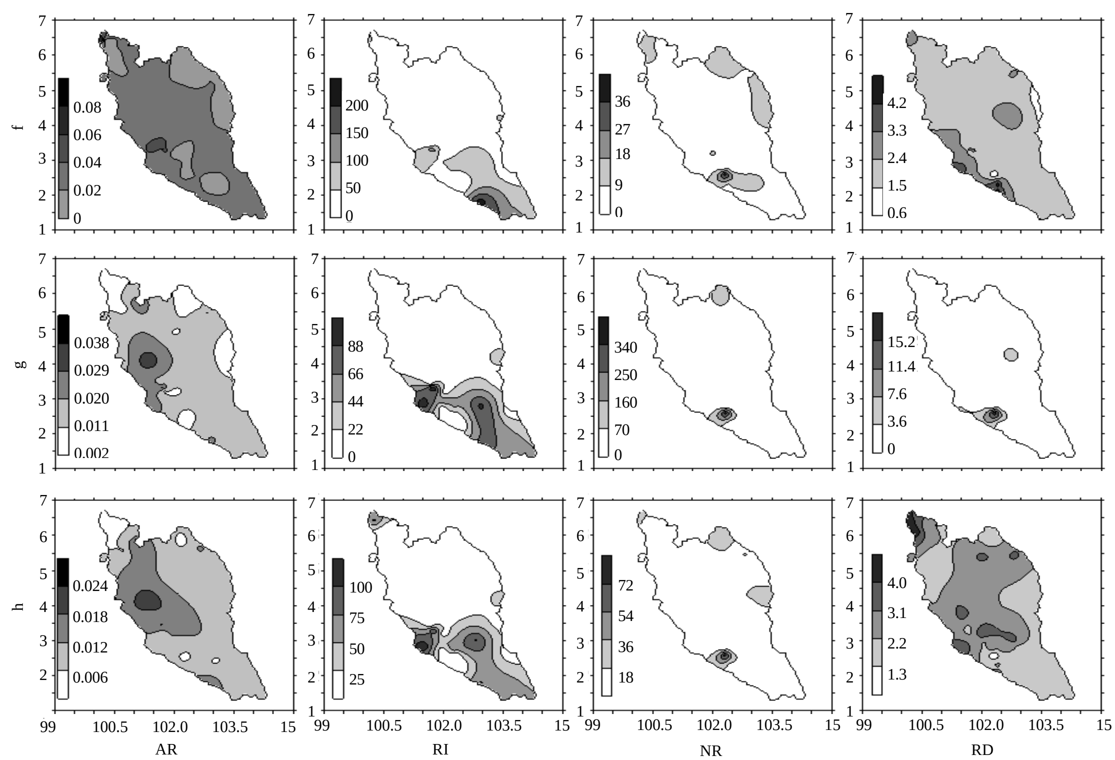

Fig. 3: Continue

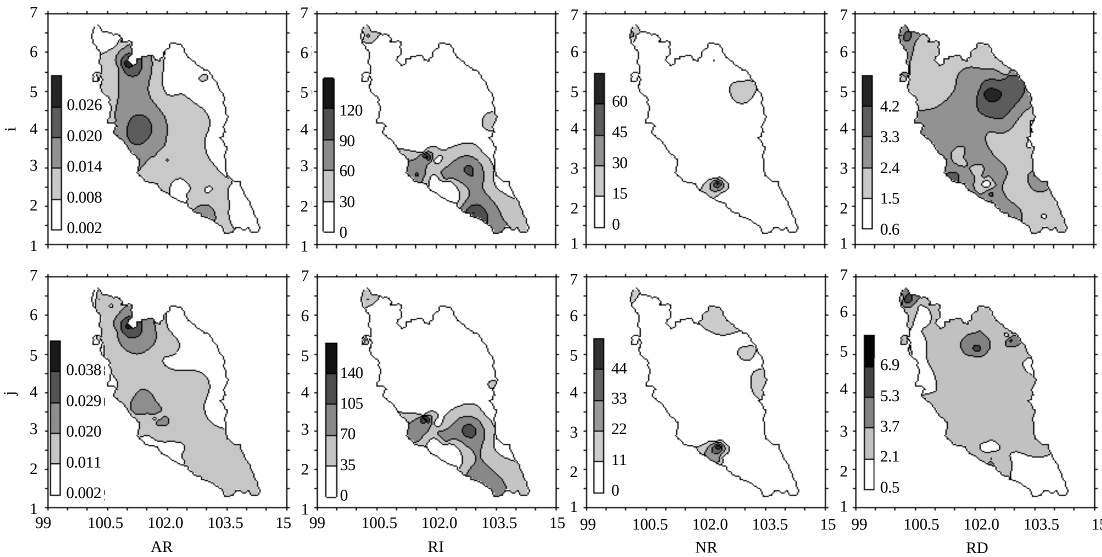

Fig. 3: NSRP Parameters during NEM: f) November; g) December; h) January; i) February and j) March

the Peninsula experienced the NR higher than during SWM season. In NEM season, the lowest NR can be found in almost all areas in Peninsula with value <9 on November and will increase significantly on December. In this season only a few small areas in West region the largest NR was observed with value >340 on November and >44 for on other months. This findings can explain that during NEM season NR higher than SWM season.

In terms of the RD, it can be concluded that almost all areas in the Peninsula experienced the same RD not more than 4.2 h, only a few places in the North recorded more than 5.6 h during the SWM season. During the NEM season, only a few places in the West recorded more than 15.2 h, particularly on December. During this season, almost all areas in the Peninsula the NR values not more than 4.2 h.

CONCLUSION

The results of this study indicate that the highest for RI and NR was found in the SouthWestern for SWM and NEM seasons and the highest AR and RD during the SWM and NEM season was found in the Eastern and Western, respectively. However, the rate of AR during NEM season is higher than during SWM season, this fact can be conclude that the storm is more common in NEM season. Based on these result, it can be argued that South West and East region can more likely be considered the wettest area during NEM season. This also explains the occurrences of floods and soil erosions more likely occur during NEM, particularly for South West and East region. The presence of the mountain ranges separating Eastern and Western parts of Peninsula could be the best reason to explain the differences in behavior storm by each region. The result of mapping important statistic, namely mean and probability of rain for 1 and 24 h during SWM and NEM season indicate that South West and East region more likely be considered wettest area.

ACKNOWLEDGEMENTS

The researchers are indebted to the staff of the Drainage and Irrigation Department and the Malaysian Meteorological Department for providing the daily rainfall data for this study. This research would not have been possible without sponsorship from Universiti Kebangsaan Malaysia (UKM). This research was funded by Universiti Kebangsaan Malaysia (DIP-2012-15) and (GP-K020448).

REFERENCES

Ananthakrishnan, R. and M.K. Soman, 1989. Statistical distribution of daily rainfall and its association with the coefficient of variation of rainfall series. Intl. J. Climatol., 9: 485-500.

Aravena, J.C. and B.H. Luckman, 2009. Spatio-temporal rainfall patterns in southern South America. Intl. J. Climatol., 29: 2106-2120.

Brunetti, M., L. Buffoni, M. Maugeri and T. Nanni, 2000. Precipitation intensity trends in Northern Italy. Int. J. Climatol., 20: 1017-1031.

Brunetti, M., M. Colacino, M. Maugeri and T. Nanni, 2001. Trends in the daily intensity of precipitation in Italy from 1951 to 1996. Intl. J. Climatol., 21: 299-316.

Burgueno, A., C. Serra and X. Lana, 2004. Monthly and annual statistical distributions of daily rainfall at the Fabra Observatory (Barcelona, NE Spain) for the years 1917-1999. Theor. Appl. Climatol., 77: 57-75.

Burgueno, A., M.D. Martinez, C. Serra and X. Lana, 2010. Statistical distributions of daily rainfall regime in Europe for the period 1951-2000. Theor. Appl. Climatol., 102: 213-226.

Burgueno, A., M.D. Martinez, X. Lana and C. Serra, 2005. Statistical distributions of the daily rainfall regime in Catalonia (Northeastern Spain) for the years 1950-2000. Int. J. Climatol., 25: 1381-1403.

Cowpertwait, P.S., 1991. Further developments of the Neyman-Scott clustered point process for modeling rainfall. Water Resour. Res., 27: 1431-1438.

Cowpertwait, P.S.P., P.E. O'Connell, A.V. Metcalfe and J.A. Mawdsley, 1996. Stochastic point process modelling of rainfall I Single-site fitting and validation. J. Hydrol., 175: 17-46.

Dale, W.L., 1959. The rainfall of Malaya, part I. J. Trop. Geogr., 13: 23-37.

Deni, S.M., A.A. Jemain and K. Ibrahim, 2010b. The best probability models for dry and wet spells in Peninsular Malaysia during monsoon seasons. Int. J. Climatol., 30: 1194-1205.

Deni, S.M., J. Suhaila, W.Z. Wan Zin and A.A. Jemain, 2010a. Spatial trends of dry spells over Peninsular Malaysia during monsoon seasons. Theoretical Applied Climatol., 99: 357-372.

Deni, S.M., S. Jamaludin, W.Z.W. Zin and A.A. Jemain, 2008. Tracing trends in the sequences of dry and wet days over Peninsular Malaysia. J. Environ. Sci. Technol., 1: 97-110.

Favre, A.C., A. Musy and S. Morgenthaler, 2004. Unbiased parameter estimation of the Neyman-Scott model for rainfall simulation with related confidence interval. J. Hydrol., 286: 168-178.

Frich, P., L.V. Alexander, P.M. Della-Marta, B. Gleason and M. Haylock *et al*., 2002. Observed coherent changes in climatic extremes during the second half of the twentieth century. Clim. Res., 19: 193-212.

Gong, D.Y., P.J. Shi and J.A. Wang, 2004. Daily precipitation changes in the semi-arid region over Northern China. J. Arid Environ., 59: 771-784.

Khalid, K., M.F. Alib, N.F. Manc, N.F.A. Rahman and A.A. Yaccob *et al*., 2016. Rainfall data analysis in Langat river basin using hyfran-plus. J. Eng. Appl. Sci., 11: 2360-2365.

Lana, X., M.D. Martinez, C. Serra and A. Burgueno, 2004. Spatial and temporal variability of the daily rainfall regime in Catalonia (Northeastern Spain), 1950-2000. Intl. J. Climatol., 24: 613-641.

Manton, M.J., P.M. Della-Marta, M.R. Haylock, K.J. Hennessy and N. Nicholls *et al*., 2001. Trends in extreme daily rainfall and temperature in Southeast Asia and the South Pacific: 1961-1998. Int. J. Climatol., 21: 269-284.

Martinez, M.D., X. Lana, A. Burgueno and C. Serra, 2007. Spatial and temporal daily rainfall regime in Catalonia (NE Spain) derived from four precipitation indices, years 1950-2000. Intl. J. Climatol., 27: 123-138.

Othman, M., Z.H. Ash'aari and N.D. Mohamad, 2015. Long-term daily rainfall pattern recognition: Application of principal component analysis. Procedia Environ. Sci., 30: 127-132.

Piccarreta, M., D. Capolongo and F. Boenzi, 2004. Trend analysis of precipitation and drought in Basilicata from 1923 to 2000 within a Southern Italy context. Intl. J. Climatol., 24: 907-922.

Rodriguez-Iturbe, I., D.R. Cox and V. Isham, 1987. Some models for rainfall based on stochastic point processes. Proceedings of the Royal Society of London A: Mathematical, Physical and Engineering Sciences Vol. 410, April 8, 1987, The Royal Society, London, England, pp: 269-288.

Shakib, S.H., H.S. Rastegari and A.R. Mahmoei, 2016. Use of ANFIS for rainfall-runoff predictions (case study: Chehel-chai watershed, Golestan province, Iran). J. Eng. Appl. Sci., 11: 3185-3192.

Soman, M.K. and K.K. Kumar, 1990. Some aspects of daily rainfall distribution over India during the South-West monsoon season. Intl. J. Climatol., 10: 299-311.

Suhaila, J. and A.A. Jemain, 2007. Fitting daily rainfall amount in malaysia using the normal transform distribution. J. Applied Sci., 7: 1880-1886.

Suhaila, J. and A.A. Jemain, 2009b. A comparison of the rainfall patterns between stations on the East and the West coasts of Peninsular Malaysia using the smoothing model of rainfall amounts. Meteorol. Appl., 16: 391-401.

Suhaila, J. and A.A. Jemain, 2009a. Investigating the impacts of adjoining wet days on the distribution of daily rainfall amounts in Peninsular Malaysia. J. Hydrol., 368: 17-25.

Suhaila, J., S.M. Deni, W.Z.W. Zin and A.A. Jemain, 2010. Spatial patterns and trends of daily rainfall regime in Peninsular Malaysia during the southwest and northeast monsoons: 1975-2004. Meteorol. Atmos. Phys., 110: 1-18.

Tick, L.J. and A.A. Samah, 2004. Weather and Climate of Malaysia. 1st Edn., University Malaya Perss, Kuala Lumpur, ISBN: 9831001761.

Turkes, M., T. Koc and F. Saris, 2008. Spatiotemporal variability of precipitation total series over Turkey. Intl. J. Climatol., 29: 1056-1074.

Wan Zin, W.Z., J. Suhaila, S.M. Deni and A.A. Jemain, 2010. Recent changes in extreme rainfall events in Peninsular Malaysia: 1971-2005. Theoretical Applied Climatol., 99: 303-314.

Wong, C.L., R. Venneker, S. Uhlenbrook, A.B.M. Jamil and Y. Zhou, 2009. Variability of rainfall in Peninsular Malaysia. Hydrol. Earth Syst. Sci. Discuss., 6: 5471-5503.

Yendra, R., A.P. Desvina, W.Z.W. Zin, A.A. Jemain and A. Fudholi, 2015. Neyman scott rectangular pulse modeling for storm rainfall analysis in Peninsular Malaysia. Res. J. Appl. Sci. Eng. Technol., 11: 841-846.

Yendra, R., W.Z.W. Zin, A.A. Jemain and A. Fudholi, 2017. Spatial analysis of storm behavior in Peninsular Malaysia during monsoon seasons. Intl. J. Appl. Eng. Res., 12: 2559-2566.

Zhang, Q., C.Y. Xu, M. Gemmer, Y.D. Chen and C. Liu, 2009. Changing properties of precipitation concentration in the Pearl River basin, China. Stochastic Environ. Res. Risk Assess., 23: 377-385.