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Recent changes in extreme rainfall events in Peninsular Malaysia: 1971–2005

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Abstract This paper assesses recent changes in extremes of annual rainfall in Peninsular Malaysia based on daily rainfall data for ten rain-gauged stations over the period 1971–2005. Eight indices that represent the extreme events are defined and analyzed. Maps of trends for these indices, which are extreme dry spell (XDS), extreme rain sum (XRS), extreme wet day intensities at 95% and 99% percentiles (I95 and I99), proportion of extreme wet day to the total wet day (R95 and R99), and frequency of extreme wet day at 95% and 99% percentiles (N95 and N99), were analyzed based on annual data and seasons. When the indices are evaluated annually, the Mann–Kendall and linear regression trend tests showed increasing trends in the extreme intensity indices (I95 and I99) at two stations. A significant decrease in N99, associated with the frequency of extremely wet days, was observed at 60% of the stations. The change points for these indices are found to occur in the period of the 1980s. There is no significant trend detected for XDS, XRS, and proportion of extreme rainfall over total rainfall amount indices during the period considered in this study. Descriptive analysis of indices

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during the monsoon period showed that the annual spatial pattern for the peninsula is very much influenced by the northeast monsoon where the highest mean values for majority of the indices occur during this time period.

1 Introduction

Extreme precipitation events, which include extreme rainfall and extremely long spell of dry days (drought), are among the most disruptive of atmospheric phenomena. In 2005, several areas in Peninsular Malaysia have resorted to water rationing due to a period of drought. In the case of extreme rainfall events, they adversely affect urban populations because the infrastructure is often inadequate to accommodate flooding caused by these infrequently occurring events. In agricultural areas, crops can suffer damage from excess rainfall as well as extreme dry spells (XDS). Since the distribution of precipitation is skewed toward large amounts, a few events can affect the seasonal total at an individual station, and therefore, the adequacy of the fresh water supply (if it is locally derived) depends on the occurrence of such events (Gershunov and Barnett 1998).

The IPCC 4th Assessment Report (Bernstein et al. 2007) indicated that some extreme weather events have changed in frequency and/or intensity over the last 50 years (1900 to 2005). This includes the increase in the frequency of heavy precipitation events (or proportion of total rainfall from heavy falls) over most areas. Over this period, precipitation increased significantly in the eastern parts of North and South America, northern Europe, and northern and central Asia, whereas precipitation declined in the Sahel, the Mediterranean, southern Africa, and parts of southern Asia. This finding agrees with several studies done throughout the Asia-Pacific region. Iwashima and Yamamoto (1993)

analyzed daily rainfall from 1890 to 1980 at 55 Japanese stations and found an increase in recent decades. Suppiah and Hennessy (1998) found increasing trends in the 90th percentile daily rainfall in tropical Australia for the months of September–April from 1910 to 1990. Alexander et al. (2006) found that precipitation indices show a tendency towards wetter conditions throughout the twentieth century based on global data for the period 1901–2003 for approximately 600 precipitation stations. Manton et al. (2001), Griffiths et al. (2003, 2005), Klein Tank et al. (2006) have conducted studies on changes in daily temperatures and extreme precipitation events in the Asia region. Manton et al. (2001) found that, for Malaysia, there is a significant decrease in rain days at all stations in the peninsula but there were no other significant trends in extreme rainfall indices. Their study also revealed that there was a significant positive trend in the number of warm nights with a large peak in 1998 and a significant decrease in the frequency of cool days and cold nights.

During the late 1990s, several international workshops developed indices for climate extremes (Jones et al. 1999; Karl et al. 1999). The aim was to create a set of indices that could be calculated for a variety of climates to enable intercomparison between regions. As a result, 27 extreme climate change indices were identified, derived from daily temperature and precipitation data (refer to ccma.seos.uvic.ca/ETCCDMI/list_27_indices.html). The Southeast Asia and the Pacific were identified as key regions (Manton and Nicholls 1999), in particular, because of its vulnerability with regard to high population density, heightened rainfall variability due to El Niño-Southern Oscillation, low-lying islands, coral reefs, and exposure to tropical cyclones. In 1998, the Asia-Pacific Network for Global Change Research funded a workshop on climate indices, and the results for this region were published in Manton et al. (2001).

This research provides an insight to the possible change in the daily rainfall extreme and XDS for the past 35 years as measured by eight extreme indices over Peninsular Malaysia using daily rainfall data over the period 1971–2005 for ten rain-gauged stations. The paper is organized as follows: Section 2 presents the data and methods used in the study, Section 3 presents the results, and Section 4 presents the conclusions.

2 Data and methods

Peninsular Malaysia lies entirely in the equatorial zone, situated in the northern latitude between 1° and 6° N and the eastern longitude from 100° to 103° E. The climate of Peninsular Malaysia is influenced by the southwest (SW) monsoon from May to August and the northeast (NE)

monsoon from November until February. The latter monsoon brings about heavier rainfall in the peninsula with the worst affected areas in the east and south. In between these two monsoons are the intermonsoon periods occurring in March–April (MA) and September–October (SO), bringing intense convective rain to many areas in the peninsula.

In this study, daily rainfall data at ten stations for Peninsular Malaysia were selected based on the completeness of the data and the length of records. Table 1 and Fig. 1 show the geographical coordinates of the stations. The selection of these stations was based on missing values of <2% within the common period of 1 January 1971 to 31 December 2005. The daily rainfall data at each station was collected using manual rain gauge. The homogeneity of the data series was checked using the four types of homogeneity tests recommended by Wijngaard et al. (2003), namely, the standard normal homogeneity test, the Buishand range test, the Pettitt test, and the Von Neumann ratio test. The results showed that the total amount, mean spell, and number of daily rainfall for each rain gauge station considered in this study were homogenous. The missing values in the data series were estimated using the modified spatial interpolation method as suggested by Suhaila et al. (2008).

The problem of unavailability of a large data set is unavoidable especially in developing countries. This situation is more critical for extreme events analysis and it is highlighted as one of the key uncertainties in the IPCC 4th Assessment Report (Bernstein et al. 2007). In the report, it is stated that climate data coverage remains limited in some regions with marked scarcity in developing countries, thus making analyzing and monitoring changes in extreme events, including extreme frequency and intensity of precipitation, more difficult than for climatic averages as longer data time series of higher spatial and temporal resolutions are required. Despite this, analysis needs to be

Table 1 Geographic coordinates and altitudes for ten rain-gauged stations in Peninsular Malaysia

Rain gauge stations	Latitude	Longitude	Altitude(m)
Alor Star	6°12′ N	100°24′ E	3.9
Bayan Lepas	5°18′ N	100°16′ E	2.8
Ipoh	4°34′ N	100°06′ E	40.1
Sitiawan	4°13′ N	100°42′ E	7
Subang	3°07′ N	101°33′ E	16.5
Petaling Jaya	3°06′ N	100°39′ E	60.8
Melaka	2°16′ N	102°15′ E	8.5
Mersing	2°27′ N	103°50′ E	43.6
Kuantan	3°47′ N	103°13′ E	15.3
Kota Bharu	6°10′ N	102°17′ E	4.6

Fig. 1 Location of stations used in this study
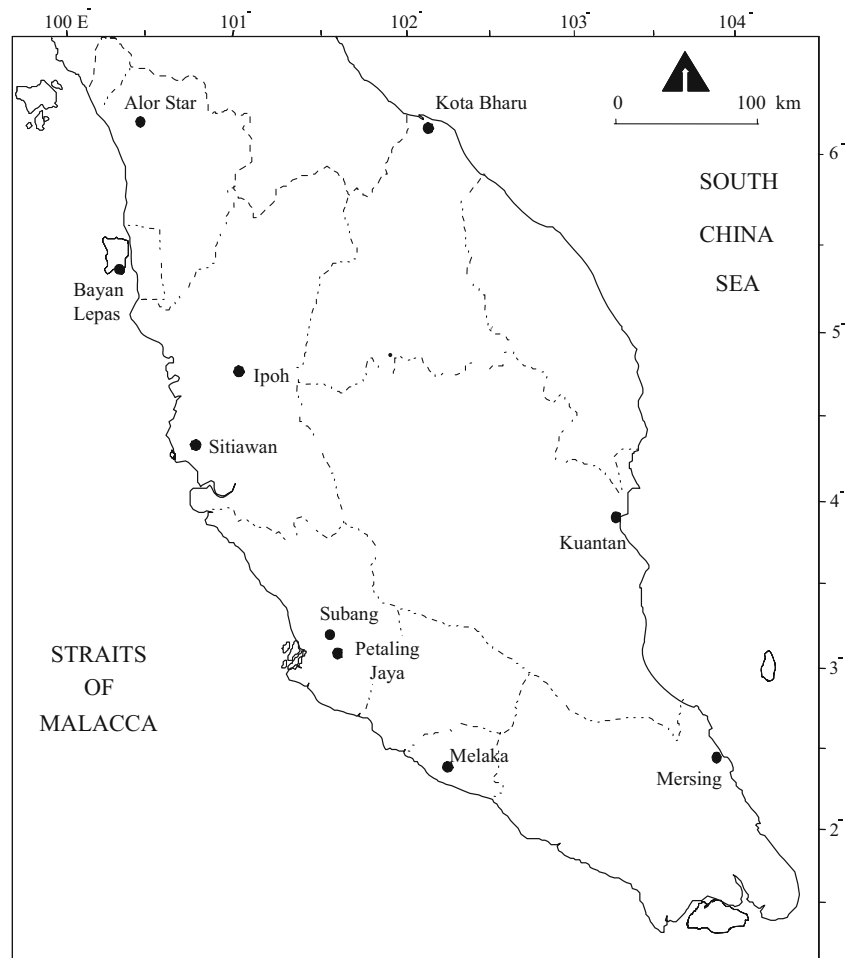
carried out as to identify any possible change in extreme weather event for this region as the impact from extreme events is often severe.

Eight extreme indices were examined based on daily rainfall data at ten stations. Some of the indices chosen are standard extreme precipitation indices as defined by The Expert Team on Climate Change Detection, Monitoring and Indices (ETCCDMI). Similar studies using the indices in this paper can also be found in publications by Manton et al. (2001), Griffiths et al. (2003), Seleshi and Camberlin (2006), and Dufek and Ambrizzi (2008). The ETCCDMI indices considered in this study are maximum dry spell, extreme intensities, extreme frequencies, and extreme proportions (Table 2). A wet day is defined as a day with

Table 2 Rainfall indices with their definition and units

|	Definitions (units)	Indicator name (ID)
1	Maximum number of consecutive dry days (days)	Dry spell (XDS)
2	The maximum cumulative total rainfall collected during a wet spell in a year (mm)	Extreme rain sum (XRS)
3	Average intensity of events greater than or equal to the 95th percentile, i.e., average 18 wettest events (mm)	Very wet day intensity (I95)
4	Average intensity of events greater than or equal to the 99th percentile, i.e., average four wettest events (mm)	Extremely wet day intensity (I99)
5	Percentage of total rainfall from events greater than or equal to the 95th percentile (%)	Very wet day proportion (R95)
6	Percentage of annual total rainfall from events greater than or equal to the 99th percentile (%)	Extremely wet day proportion (R99)
7	Frequency of daily rainfall exceeding the 1971–2005 mean 95th percentile (days)	Very wet days (N95)
8	Frequency of daily rainfall exceeding the 1971–2005 mean 99th percentile (days)	Extremely wet days (N99)

"Events" is the daily rainfall rate
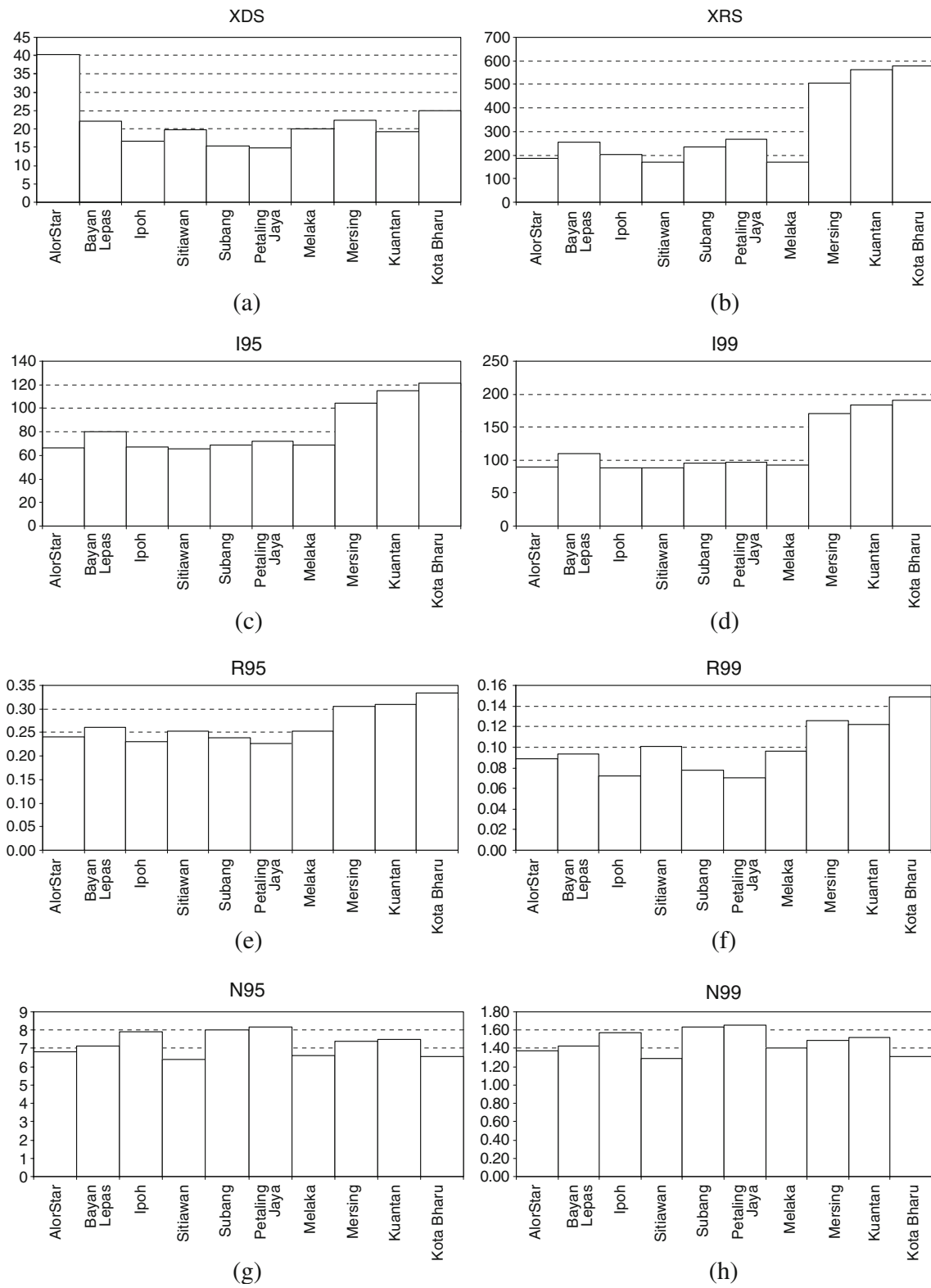
Fig. 2 Histogram of mean average extreme indices at each of the ten rain gauge stations where indices are **a** XDS, **b** XRS, **c** I95, **d** I99, **e** R95, **f** R99, **g** N95, and **h** N99

Fig. 3 Spatial distribution of mean values for all extreme indices considered in this study where indices are **a** XDS, **b** XRS, **c** I95, **d** I99, **e** R95, **f** R99, **g** N95, and **h** N99
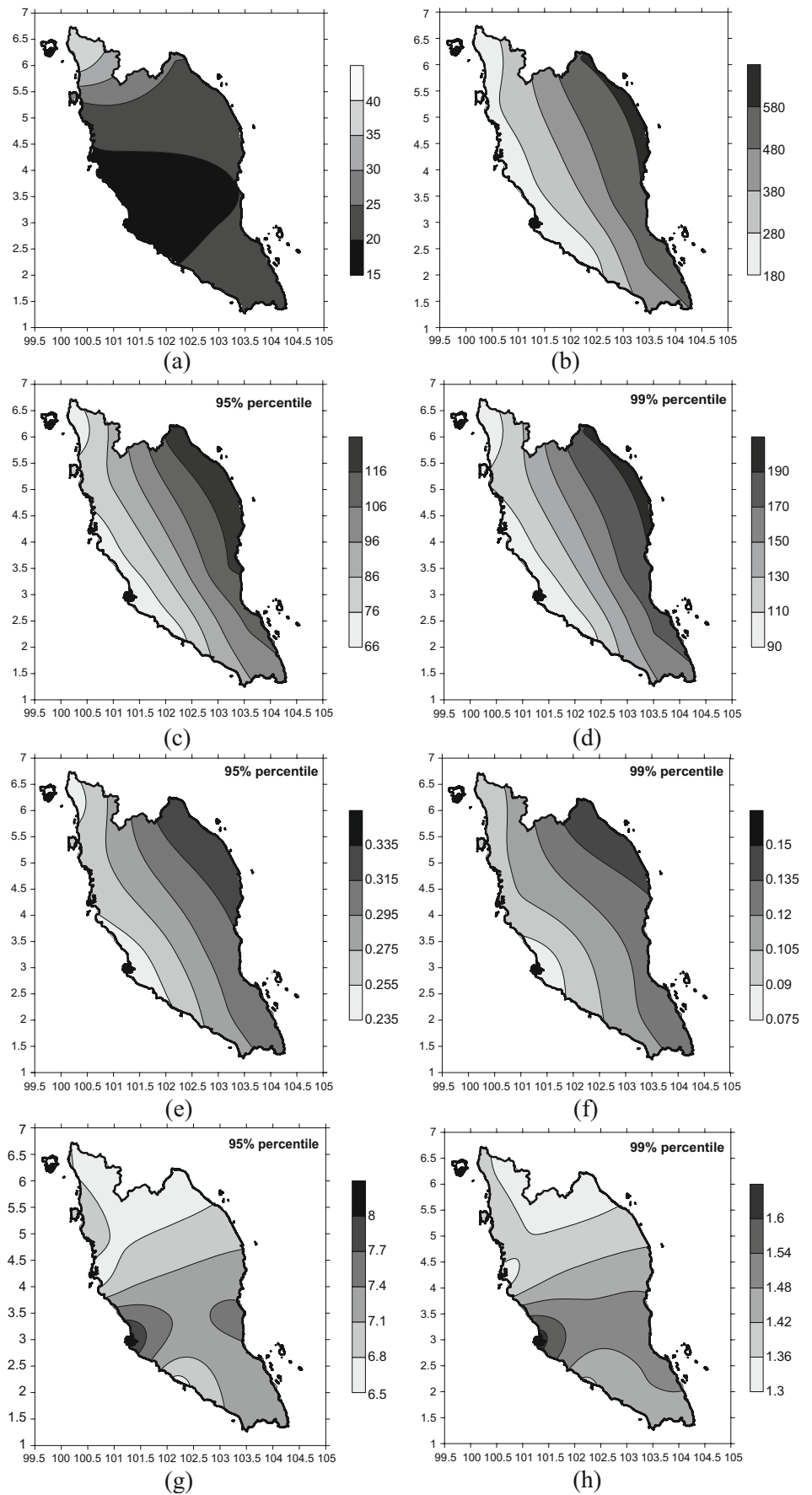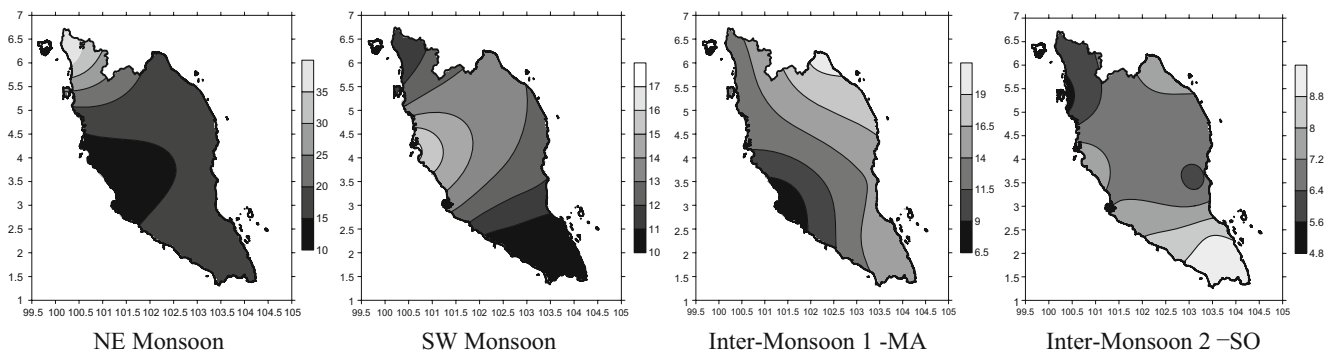
Fig. 4 Spatial distribution of the average of index XDS (in days per year) for the four seasons

a rainfall amount of at least 1 mm. Tolika and Maheras (2005) mentioned that the selection of a threshold in order to define a wet/dry day is not fixed; instead, it depends on certain characteristics, the climate, and the needs of each particular study area. Another level which is often selected as a threshold is 0.1, also known as the resolution of a pluviometer; however, this level is not chosen in this analysis as it is a relatively low level for an area with high humidity such as Peninsular Malaysia. The dry spell index calculates the longest dry spell (rainfall amount <1 mm) recorded each year. The extreme rain sum index measures the greatest cumulative rainfall amount received during a wet spell in a year. This index is considered as flooding usually occurs when infrastructure is unable to accommodate the amount of excess water during prolonged and continuous rainy days. The 95th and 99th percentiles are selected as the thresholds to represent extreme events. As there are, on average, 365 days in a year, the 95th and 99th percentiles correspond to the 18th and fourth highest rainfall at annual time scale, respectively. Extreme proportion measures the proportion of annual rainfall that comes from the highest 18 and four rainfalls each year. Extreme frequency is a count of rainfall events per year which equal to or above the long-term (1971–2005) mean 95th and 99th percentiles. We will refer to rainfall exceeding 95th

percentile as very wet days and exceeding the 99th percentile as extremely wet days.

Trends based on the resulting series were estimated for each index at the ten stations using a least square linear fitting. The slope of the linear trends, which gives the rate of change per year, was calculated and the significance of this linear fit was tested using t test at 5% level of significance. Another test to detect the trend within the time series is the nonparametric Mann–Kendall test (Mitchell et al. 1996). In the Mann–Kendall test, for each element x_i ($i=1,...,n$) of the series, the number n_i of lower elements x_j ($x_j<x_i$) preceding it ($j<i$) is calculated and the test statistics t is given by $t = \sum_i n_i$. In the absence of any trend (null hypothesis), t is asymptotically normal, independently from the distribution function of the data, and has a standard normal distribution with $\overline{t}$ and var(t) given by $\overline{t} = \frac{n(n-1)}{4}$ and $\mathrm{var(t)} = \frac{n(n-1)(2n+5)}{72}$. The test statistic, $u(t) = \frac{(t-\overline{t})}{\sqrt{\mathrm{var(t)}}}$, are then computed where null hypothesis can, therefore, be rejected for high values of $|u(t)|$. In this analysis, the significant level is chosen at $\alpha=0.05$, thus $|u(t)| > 1.96$ will indicate significant trend.

Identification of abrupt changes (also called change points or climatic jumps) in a time series is viewed as complementary to the analysis of trends for a given time period (Tarhule and Woo 1998). The Mann–Kendall test
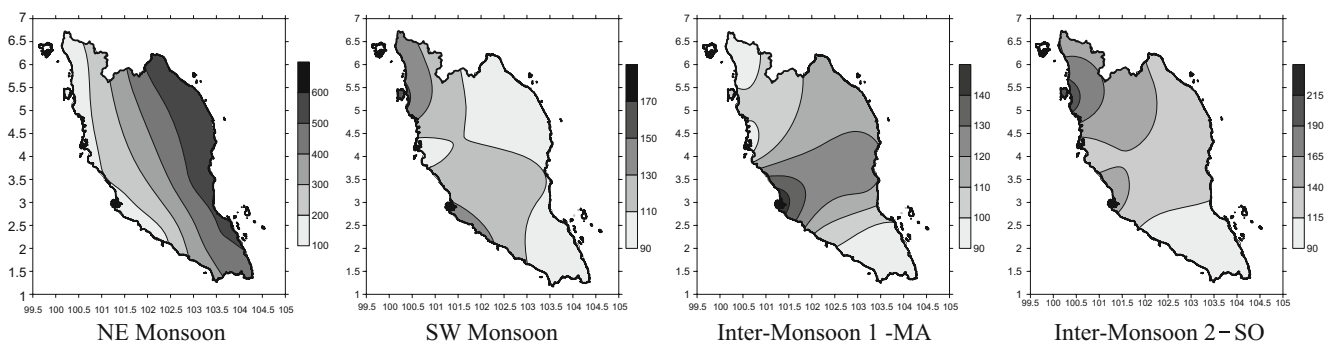

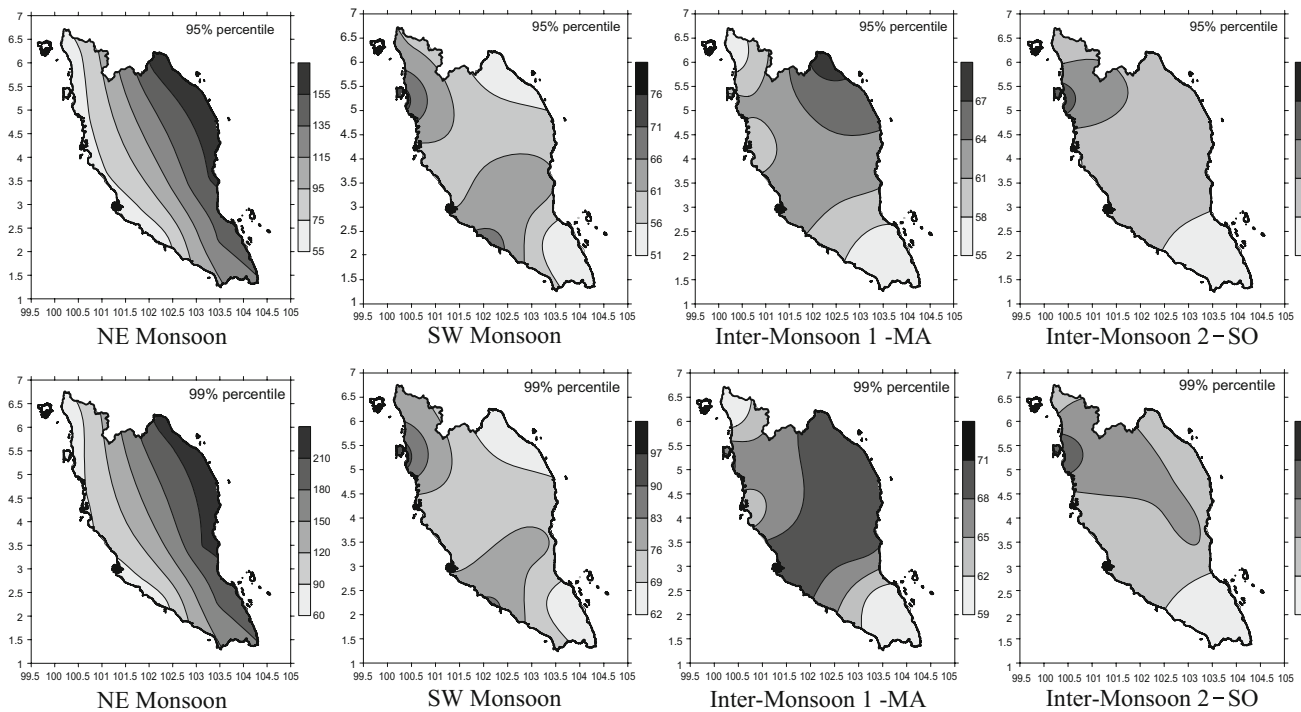Fig. 5 Spatial distribution the average of index XRS (in millimeters per year) for the four seasons

Fig. 6 Spatial distribution of the average of index I (in millimeters per year) for the 95th and 99th percentiles

merely indicates whether there exists any trend within the time period considered at a particular area. It does not provide information on where the point of change in a data series occurs. Thus, for the purpose of locating the change point, the Pettitt test (1979) will be used. It has been

demonstrated by Sneyers (1990) and Aondover and Woo (1998) that the Pettitt test is a useful technique for examining the occurrence of abrupt changes in climatic records. This test signals a change in a series of observations with no assumptions made about the distribu-
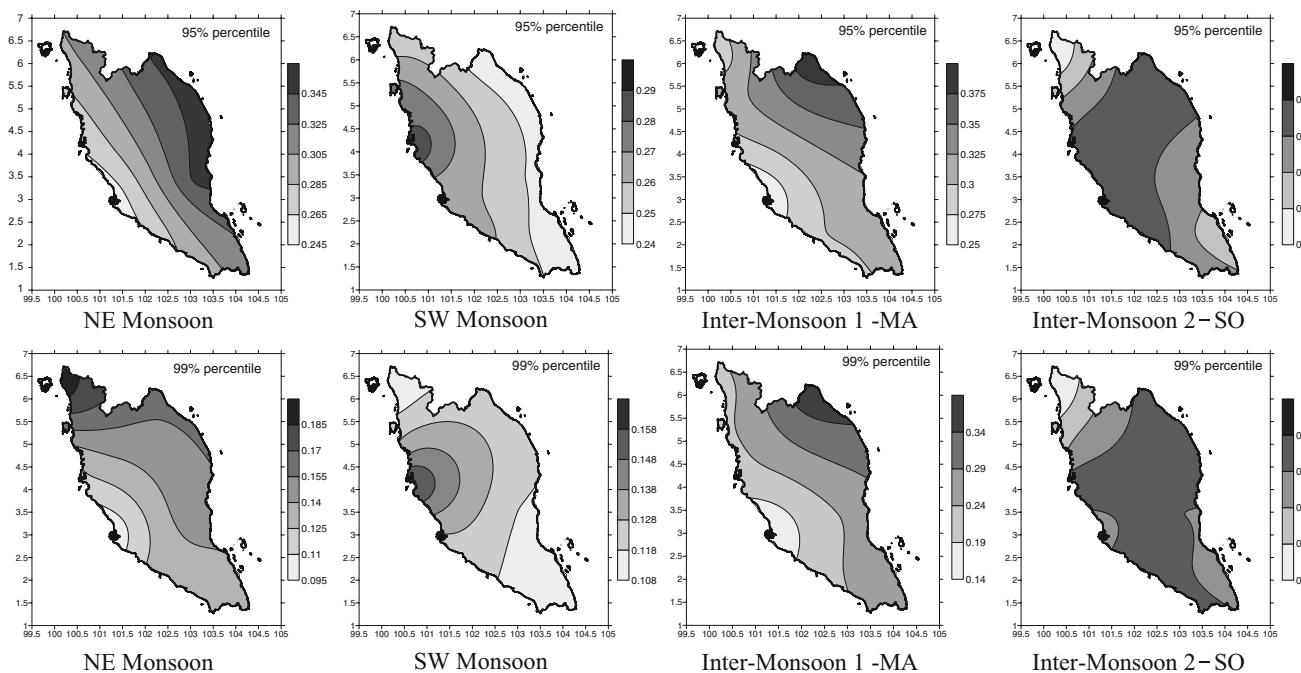

Fig. 7 Spatial distribution of the average of index R (in millimeters per year) for the 95th and 99th percentiles
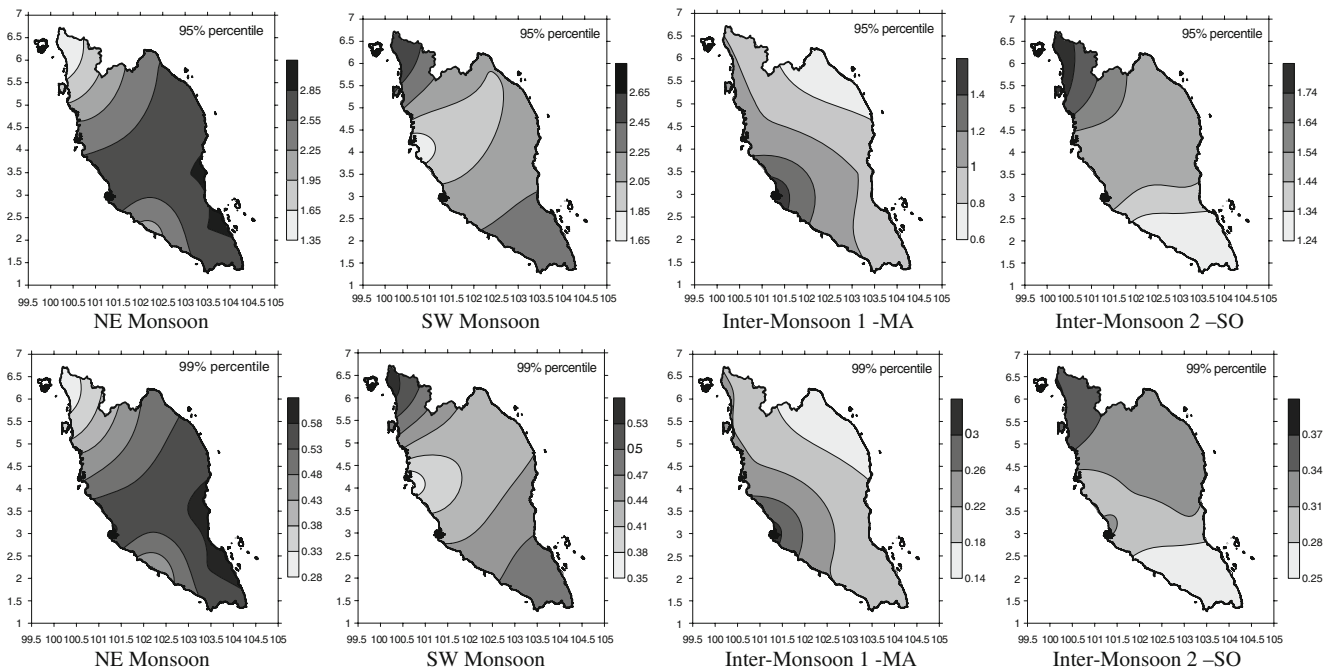
Fig. 8 Spatial distribution of the average of index N (in millimeters per year) for the 95th and 99th percentiles

tion of the variable (Pettitt 1979). In this test, firstly, the statistic $U_k = 2\sum_{i=1}^{k} M_i - k(n+1)$ is calculated where M_i is the rank of the ith observation when the values $X_1, X_2, \ldots, X_n$ in the series are arranged in ascending order. The statistical change point test statistic is $K = \max_{1 \le k \le n} |U_k|$. The critical value for the Pettitt test is $K_\alpha = \left[\frac{-\ln\alpha\left((n^3+n^2)\right)}{6}\right]^{\frac{1}{2}}$.

3 Results

3.1 Mean spatial and seasonal pattern

Figure 2 displays the histogram plots of the mean values of the indices at each station while Fig. 3 illustrates the spatial distribution of the means over the peninsula. Short XDS is observed over the southwestern part of the peninsula with a minimum of 14.71 at Petaling Jaya. Alor Star, located at the northern part of the peninsula, has the longest XDS, recording a mean of 40.34 consecutive days without rain. Kota Bharu, on the eastern part, recorded the highest mean for XRS, I95, I99, R95, and R99. For these indices, other stations at the eastern part of the peninsula (Kuantan and Mersing) have relatively higher mean values compared to the other parts of the region. For N95 and N99, two stations located close to each other, which are Petaling Jaya and Subang experience higher mean number of days exceeding these percentile values compared to other parts of the peninsula. For these two extreme frequencies indices, the northern part of the peninsula recorded relatively lower

values as shown in Fig. 3g, h. Sitiawan recorded the lowest average values for extreme intensities (I95 and I99) and frequencies (N95 and N99) indices.

3.2 Spatial distribution of mean values based on seasons

Climate in the peninsula is very much influenced by two monsoon seasons, which are the NE and SW monsoons. Thus, the extreme rainfall characteristics during these two monsoons as well as during the two intermonsoon seasons (MA and SO) will be considered. Figures 4, 5, 6, 7, and 8 illustrate the spatial pattern for these indices according to the four seasons. As the numbers of days for the four seasons are not the same, only extreme intensities (I95 and I99) indices will be compared across the four different seasons. It is found that the highest mean for I95 and I99 occur during the NE with Kota Bharu recording the highest mean for these indices during the NE but the same station recording the lowest during the SW. The lowest mean for the extreme intensities indices occur during the first intermonsoon season, i.e., MA.

With regards to the geographical distribution of indices during each season, the stations in the east receive relatively higher values for extreme indices during the NE; while during the SW, the stations in the west receive relatively higher values for extreme indices. XRS, I95, I99, and R95 have similar spatial pattern during NE with values decreasing from east to west of the peninsula. XDS is shortest at the south during SW but longest during SO. The south part of the peninsula also recorded the highest value relative to the other parts for XRS, I95, and I99 during SW,

Table 3 Linear trend (LT) for the indices over the period 1971–2005

Stations	XDS		XRS		I95		I99		R95		R99		N95		N99	
	LT	MK	LT	MK	LT	MK	LT	MK	LT	MK	LT	MK	LT	MK	LT	MK
Petaling Jaya	0.003	NST	3.218	NST	0.508*	IST	0.875*	IST	~0	NST	~0	NST	0.189*	IST	0.070*	NST
Subang	0.022	NST	1.231	NST	0.341*	IST	0.557	IST	~0	NST	~0	NST	0.065	NST	0.056	NST
Alor Star	−0.393	DST	−1.312	NST	−0.248	NST	−0.459	NST	~0	NST	~0	NST	−0.060	NST	−0.045	DST
Ipoh	−0.059	NST	1.300	NST	0.068	NST	0.509*	IST	~0	NST	~0	NST	0.059	NST	0.006	DST
Sitiawan	0.047	NST	0.421	NST	0.066	NST	−0.022	NST	~0	NST	~0	NST	0.035	NST	−0.010	DST
Bayan Lepas	−0.139	NST	−1.114	NST	0.049	NST	0.348	NST	~0	NST	~0	NST	−0.010	NST	0.007	NST
Kota Bharu	−0.164	NST	−2.957	NST	−0.617	NST	−0.679	NST	~0	NST	~0	NST	0.014	NST	−0.017	DST
Kuantan	0.023	NST	−4.036	NST	−0.128	NST	0.064	NST	~0	NST	~0	NST	0.019	NST	−0.009	NST
Mersing	0.043	NST	−7.609	NST	−0.726	NST	−1.487	NST	~0	NST	~0	NST	−0.051	NST	−0.031	DST
Melaka	−0.161	NST	−1.179	NST	−0.025	NST	−0.257	NST	~0	NST	~0	NST	0.003	NST	−0.023	DST

The Mann–Kendall (MK) trend test result is indicated as NST for no significant trend, IST for increasing significant trend, and DST for decreasing significant trend at the 95% level. Statistically significant linear trends at the 95% level are denoted with an asterisk

~ approximate

MA, and SO. The spatial distribution for R95 and R99 during NE and MA is almost similar; however, it is a contrast when comparing the same indices during the SW and MA. For N95 and N99, the values increase from north to south of the peninsula during NE and from north–east to south–west of the peninsula during MA.

3.3 Changes in extreme events

Analysis to detect any possible changes in the extreme rainfall events are done for the annual data series without any seasonality segregation. This is because we are interested to detect any significant changes in this region as one regardless of seasonality effect. In cases where significant changes are detected, reference can be made to the results in Sections 3.1 and 3.2 to identify the period when these particular changes are likely to occur. With reference to Table 3, the Mann–Kendall trend test results show that there exist increasing trends in the I95 and I99 indices for Petaling Jaya and Subang. The increase in extreme intensities for Petaling Jaya is 5.08 and 8.75 mm/ decade for I95 and I99, respectively. For Subang, the increase in extreme intensities is 3.41 and 5.57 mm/decade for I95 and I99, respectively. Petaling Jaya also recorded an increase in N95 and significant linear trend for the N99. Despite experiencing the longest mean dry spell relative to other stations, Alor Star recorded a significant decreasing trend for this index. This station also experiences a significant decreasing trend for N99. Ipoh experiences a significant increase in trend for I99 and significant decrease in trend for N99.

From Table 3, based on the Mann–Kendall test, it can be observed that 60% of the stations experience significant decrease in the N99 index. Therefore, a Monte Carlo simulation has been conducted to assess the situation at these six stations. In this simulation, firstly, the frequency of rain days in a year is generated based on the normal distribution with its mean and standard deviation computed from observational data. Next, simulation is done to compute the amount of rainfall for the rain days using gamma distribution with parameters based of observational data. From the simulation results, the N99 index is calculated and the Mann–Kendall test performed. The process is repeated 10,000 times and the Mann–Kendall result from simulated data agrees with the results for N99 as displayed in Table 3.

Analysis by linear regression line showed slightly different results compared to the results obtained using the Mann–Kendall analysis. This is because the Mann–Kendall analysis checks for step-by-step change in the trend within the time period considered while the linear regression test evaluates the changes as a whole for the period (1971–2005) in the data series.
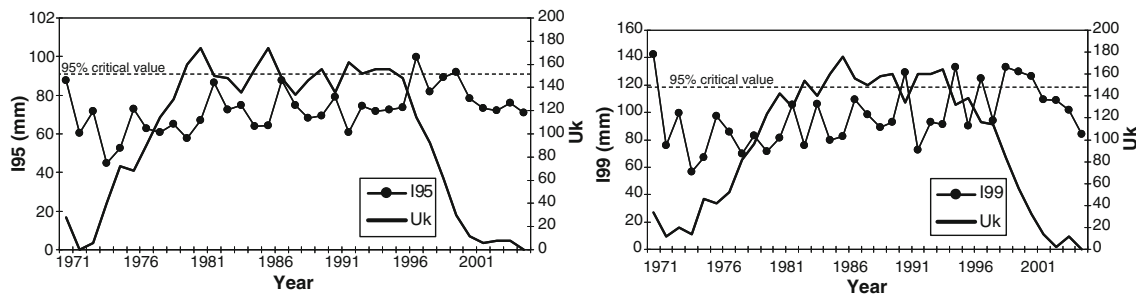
Fig. 9 Application of the Pettitt test to the time series data set of the extreme intensity indices (I95 and I99) for Petaling Jaya

The point of change for stations showing significant trends and significant linear regression for indices are also evaluated. Based on the formula given earlier, the critical value for the Pettitt test for this data is 148.39 at 5% significance level With reference to Table 3, the stations that are significant for both linear trend and Mann–Kendall tests are Petaling Jaya (I95, I99, and N95), Subang (I95), and Ipoh (I99). The Pettitt test is also performed for N99 (Petaling Jaya), I99 (Subang), and XDS (Alor Star). From Fig. 9, for Petaling Jaya for I95, the change point is identified in 1981 and 1986. I99 for this station indicates a change point in 1986. The change point for the N95 index at this station occurred in 1980 and 1986 for N99 (Fig. 10). For Subang (Fig. 11), index I95 and I99 displayed a change point in 1986. As these stations are located close to each other, it is interesting to note that the similarity in the period of change points for the indices which occurs in the 1980s. On the other hand, although both Mann–Kendall and linear regression test are significant for I99 for Ipoh (Fig. 12), the Pettitt test fails to detect the change point during the period considered. However, there is an indication of a change point in 1998, thus, the failure of the Pettitt test to recognize the significance of this change point may be due to insufficient data after this point (1998). A possible change point is identified in 1988 for XDS in Alor Star (Fig. 13).

As a complement to the Pettitt test, Student's test has been performed to test whether the change in the mean between the two subperiods separated by the change point is statistically significant. Results of the t test at 5%

significance level showed that the means prior and post the change point at Petaling Jaya (I95, I99, N95, and N99 at 1986), Subang (I95 and I99 at 1986), Ipoh (I99 at 1998), and Alor Star (XDS at 1988) are significant.

4 Conclusion

The descriptive analysis shows that the eastern region of the peninsula experiences higher amount of cumulative rainfall (XRS), extreme intensities (I95 and I99), and extreme percentage from total annual rainfall amount at extreme percentile values (R95 and R99) compared to the western part. Despite Petaling Jaya receiving the highest number of very wet days (N95) and extremely wet days (N99) relative to other stations, the contribution of rain amount derived based on these percentiles to the total rainfall amount is the lowest compared to the other stations. Segregation of the data to seasons revealed that, contrary to the general assumption that the convective rain occurring during the intermonsoon period has higher intensities compared to stratiform rain which occur during the monsoon season, this analysis showed that the highest extreme intensities occur during the NE monsoon season. The highest numbers of very wet days and extremely wet days also occur during the NE. Kota Bharu and Bayan Lepas are stations which experience the highest values in most of the considered indices during the NE and SW monsoon seasons, respectively. Comparison of spatial distribution of indices based
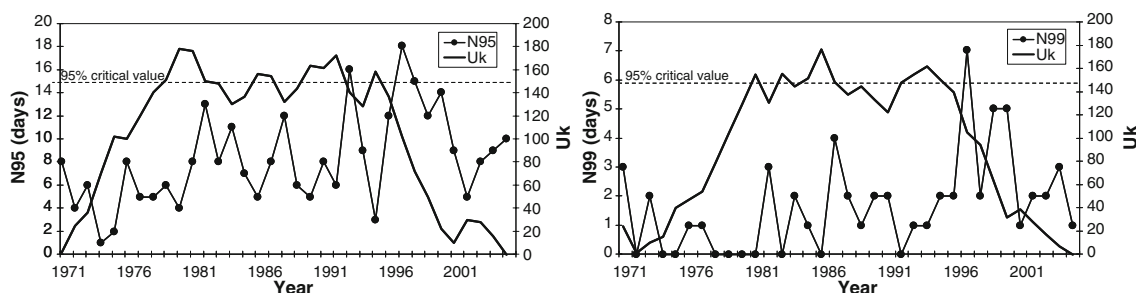

Fig. 10 Application of the Pettitt test to the time series data set of the extreme frequency indices (N95 and N99) for Petaling Jaya
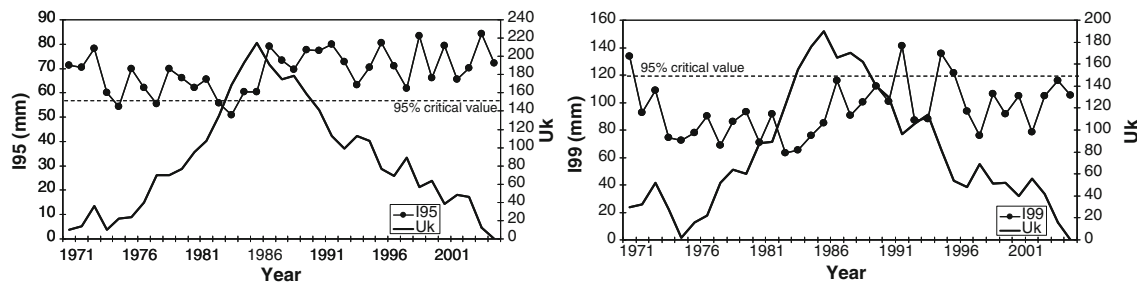
Fig. 11 Application of the Pettitt test to the time series data set of the extreme intensity indices (I95 and I99) for Subang

on annual data (Fig. 3) versus spatial distribution of indices segregated to different seasons (Figs. 4, 5, 6, 7, and 8) showed that the spatial distribution of annual indices is almost similar to the spatial distribution during the NE monsoon, implying that the NE monsoon has a greater influence in the spatial pattern of the extreme rainfall indices.

Trend analysis based on 35-year data does not show much change in the stations apart from two closely situated stations that is Petaling Jaya and Subang. Both stations share almost identical characteristics in terms of significant increase in extreme rainfall intensity. Petaling Jaya also showed an increase in the number of very wet days and extremely wet days. This findings need to be viewed with caution as these two places are heavily populated areas with intensive urbanization and the increase in the frequency of flash floods in these two areas in recent years may be partly due to these weather trend. Tangang et al. (2006) found that high warming rate, particularly in large cities could be enhanced by the urban heat island (UHI) effect, which has been considered a significant factor in the enhancement of warming rates in large cities. Several local investigations indicated the presence of the UHI effect on the local temperature changes (Shaharuddin 2005) which directly influence the intensity of rainfall at the respective area. The study, however, shows that there is no significant trend in the proportion of extreme rainfall amount to total rainfall received at all stations. It is also interesting to note that the

number of extremely wet days (values equal and exceeding the 99th percentile) showed a significant decreasing trend when tested by Mann–Kendall at 60% of the stations studied. A question possible is whether the frequency of extremely heavy rainfall has actually declined in recent years as opposed to longer extremely heavy rain days as it was previously.

The analysis also showed that the change point of significant indices at stations with significant change in trends occurred during the 1980s. The occurrence of the two most extreme El Ninos in 1982/1983 and 1997/1998 could be a strong contributing factor to the climate changes in the last few decades as indicated by this study.

Studies done by Manton et al. (2001) which covered data from 1961–1998 found that, for Malaysia, there is a significant decrease in rain days at extreme percentiles for all stations in the peninsula but there were no other significant trends in extreme rainfall indices considered. The conclusion is based on data from three stations which is also included in this study and four stations which are located on East Malaysia (not part of the peninsula). They considered the 99% percentile and the results agree with the finding for N99 in this study. Thus, we can say that the significant negative trend for frequency of extremely wet days has been observed since the 1960s and continue with recent data. In our case, we extended the study on extreme rainfall by segregating the annual data to seasons as to check for spatial pattern of extreme rainfall during each
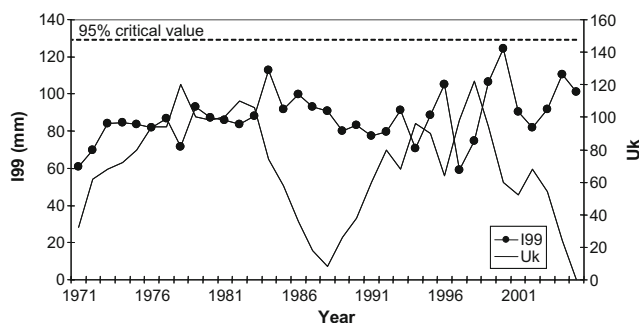

Fig. 12 Application of the Pettitt test to the time series data set of the extreme intensity index (I99) of Ipoh station
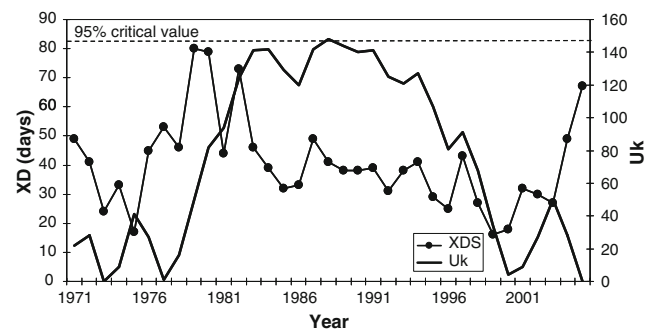

Fig. 13 Application of the Pettitt test to the time series data set of the XDS index of Alor Star station

season and we found that the annual pattern of extreme rainfall in the peninsula is highly influenced by the NE monsoon.

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