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Trends for Daily Rainfall in Northern and Southern Region of Peninsular Malaysia

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Abstract Modeling of daily rainfall data, particularly the rainfall amount, is increasingly important, not only for hydrological purposes, but also for providing input for models of crop growth, design of urban drainage systems, land management systems and other environmental projects. This paper assesses recent changes in extremes of the monthly mean rainfall distribution in Peninsular Malaysia based on two regions which is northern region (Perlis) and southern region (Johor Bahru) over the period 1970–1972 and 2010-2012. This research compare several years Descriptive statistics of the monthly rainfall amount for each rain gauge stations are summarized where the mean, standard deviation, standard error of mean, median, standard deviation, variance, range, minimum and maximum of rainfall were obtained. In this research, a comparison of the earlier year (1970-1972) and lastest year (2010-2012) show that 2010-2012 received heavy rain compared with 1970-1972 for both rain gauge stations. The highest amount of rainfall show that Station Abi Kg. Bahru, Perlis recorded 23.36 mm for 2010-2012. This trend of increasing mean rainfall can cause landslide and floods in Malaysia.

Keywords Rainfall, Climate Change, Statistic Description

1. Introduction

Climate change has altered not only the overall magnitude of rainfall but also its seasonal distribution and interannual variability worldwide (Nicholson, 2000). Such changes in the rainfall regimes will be most keenly felt in arid and semiarid regions, where water availability and timing are key factors controlling biogeochemical cycles, primary productivity, and the phenology of growth and reproduction, while also regulating agricultural production (Feng, 2013). The climate plays such a major part in our planet's environmental system that even minor changes have impacts that are large and complex (Trenberth and Kevin, 1992). Global climate change will impose serious impacts on species and ecosystems worldwide during the 21st century.

Extreme weather and climate events have received increased attention in the last few years, due to the often large loss of human life and exponentially increasing costs associated with them (Karl and Easterling 1999). In 1998 flooding and landslides due to Hurricane Mitch resulted in more than 10 000 deaths in Central America, and in 1995 economic losses on the U.S. mainland due to hurricanes averaged \$5 billion (normalized to 1995 levels) per year (Pielke and Landsea 1998). This increased attention raises the question as to whether extreme weather and climate events are truly increasing, whether this is only a perceived increase exacerbated by enhanced media coverage, or both (Karl and Easterling 1999).

Due to climate change, there will be many inter-related changes to the weather. There will be more droughts, heat waves, storms and floods. Vegetation system will also be changed. Changes in the amount and distribution of ice permafrost, snow, water and vegetation may modify the environment. The stability of natural slopes and the associated risk will be very much affected by climate. Past trend of temperature for land are show in figure 1.

Haze is no longer a new phenomenon to the Southeast Asian countries. It has become a regular problem that has to be faced by the country such as Brunei, Indonesia, Thailand, Philippines and Malaysia. This problem is caused by land and forest fires in the zones with high temperature levels in Indonesia. Besides, haze also poses threats to people's health. In this respect, rainfall is important in that it can reduce, or eliminate the effect of haze (Wang, 1993).

Floods and flash floods associated with extreme rain events are a major hydrological disaster in the Peninsular Malaysia especially during the northeast monsoon cold surge episodes (Lim and Samah, 2004; Juneng et al., 2007). The cause of floods maybe due to topographic features of the region as well as the frequency of occurrence of high intensity rain events. In the case of the northeast monsoon period, these could be due to the combined interactions of Madden–Julian Oscillation, Indian Ocean Dipole and Borneo vortex with the cold surges (Tangang et al., 2008).

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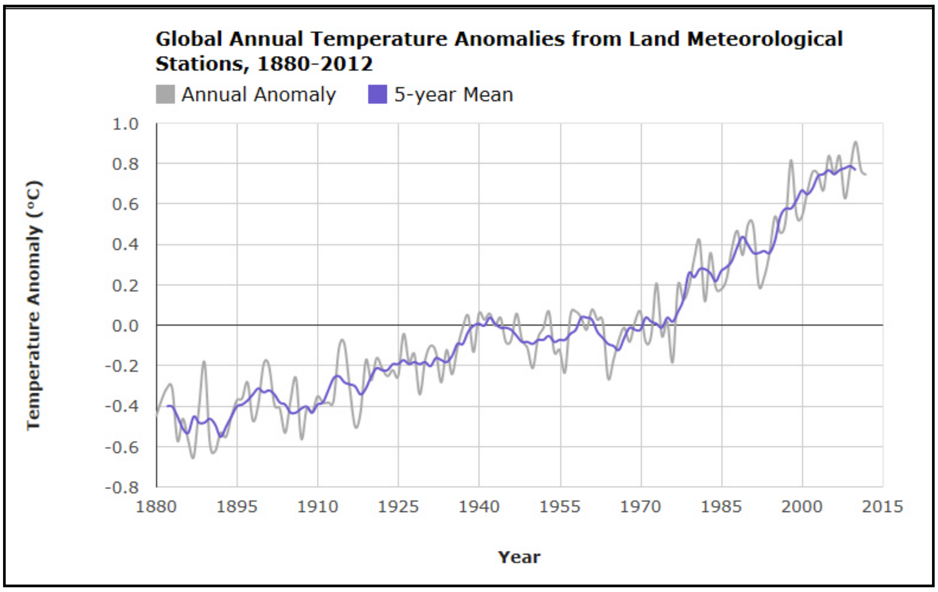


Figure 1. Global Annual Temperature Anomalies from Land Meteorological Stations, 1880-2012 (Hansen et al., 2012)

Unfortunately, heavy rainfalls could bring disaster such as floods and landslides. Of course, the shortage of rainfall could also affect the water management system in such a way it could bring problems to the economic activities (Daud et al., 2002). Therefore, there are needs to investigate the characteristic of rainfall of a country intensively and comprehensively. Modeling of daily rainfall using various mathematical models has been done throughout the world to give a better understanding about the rainfall pattern and its characteristics which involve the study on the sequence of dry and wet days and also the rainfall amount on the wet days (Jamaludin et al., 2008). In Malaysia, the climatology and hydrology of rainfall have been intensively investigated in recent years. Desa and Rakhecha (2007), Zalina et al. (2002) and Desa et al. (2001) conducted the researches on extreme rainfall series and estimation of probable maximum precipitation in Malaysia. Meanwhile, the behaviour of the Malaysian rainfall anomalies related to the El Nino-Southern Oscillation and local air sea influences has been extensively studied by Tangang et al. (2007) and Juneng and Tangang (2004, 2005).

This paper looks at the trend of rainfall in two regions of Malaysia and compares the mean rainfall amount for the past and present years.

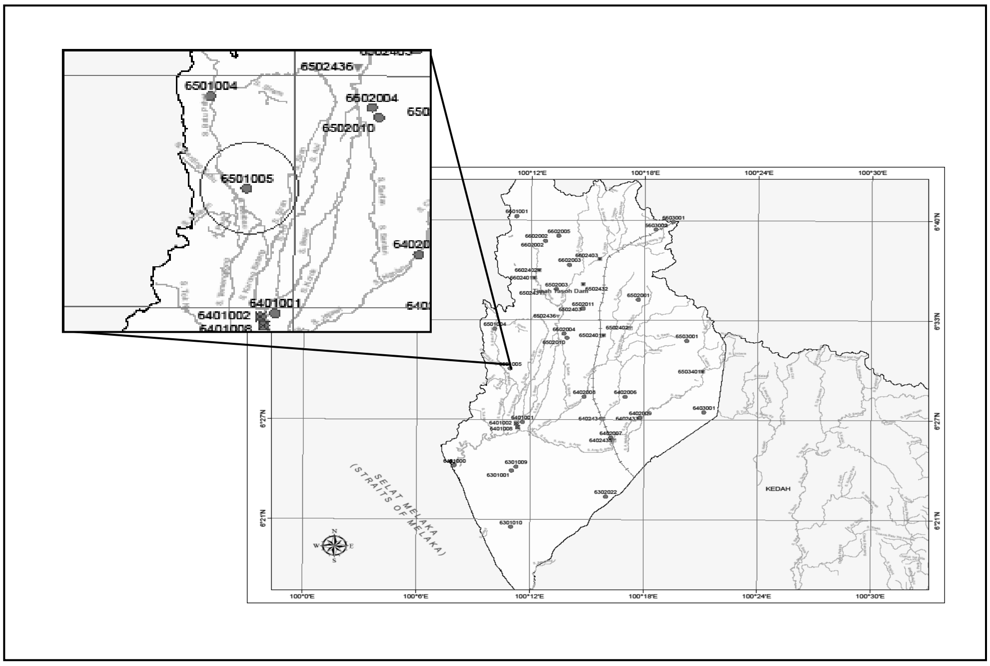
2. Methodology

Monthly rainfall series data for this study have been obtained from Department of Irrigation and Drainage Malaysia for the period from 1970-1972 and 2010-2012. For this study, two rain gauge stations were chosen based on the region, which is one at the northern region and the other one at southern region of Peninsular Malaysia. The southern region is situated at Stor JPS at Johor Bahru, Johor and for the northern region is situated at Abi Kampung Bahru, Perlis.

The state of Johor with an area of 19,984 km^2 is situated at the southern end of Peninsular Malaysia. It was named after the Sungei Johor which is the largest river in the state. Because of its proximity to the equator and also maritime exposure, the state is blessed with a uniform temperature, pressure, high humidity and abundant rainfall all the year round. The average annual temperature is about 26 °C. The climate of the state is equatorial and the year can be divided into two main seasons, the northeast monsoon (December to March) and the southwest monsoon (June to September) separated by two relatively short intermonsoon periods. During the northeast monsoon season, northeast winds prevail with speed reaching 20 km/h Cloudy conditions in December and January with frequent afternoon showers, spells of widespread moderate to heavy rain can last for a duration of 1 to 3 days continuously. During the southwest monsoon, southwest winds tend to prevail.

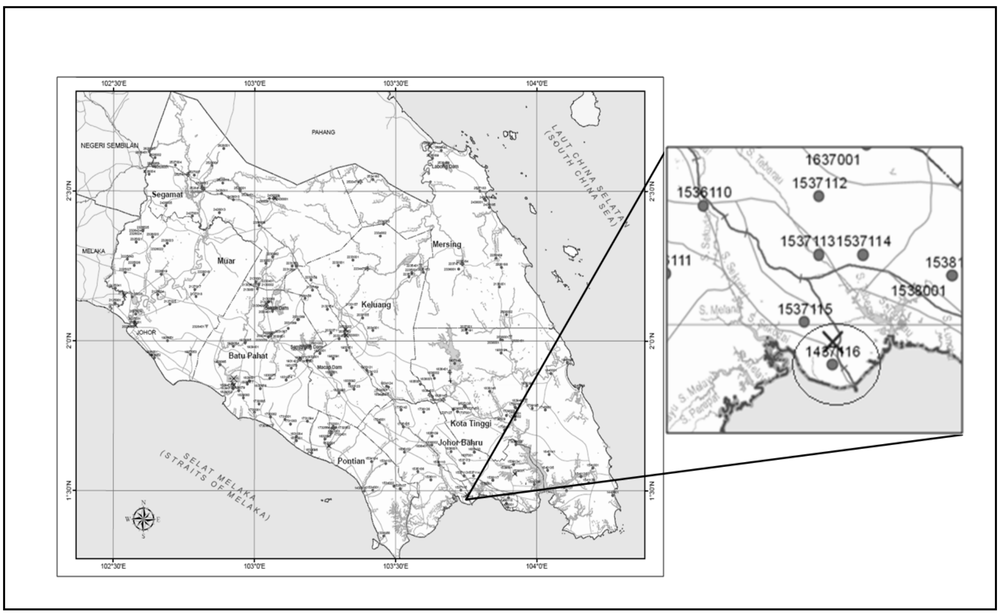
Perlis lies at the northwestern tip of the Peninsular Malaysia bounded by Thailand in the north, and by Kedah to the east and south. Its western coastline borders the Straits of Malacca. It measures approximately 810 km^2 and has a population of 217,480. The state capital is Kangar while Arau, 10 km away, is the Royal town. The locations for these stations are on map in Figure 1 and 2.

Descriptive statistics were used to determine the characteristics of the data in this study. Seven important characteristics were showed such as mean, median, standard deviation, variance, range, minimum and maximum values. Descriptive statistics such as mean, median, minimum and maximum values, standard deviation and variance of the monthly mean rainfall amount from 1970-1972 and 2010-2012 for each region were obtained. The differences among the stations can be compared through the mean, standard deviation, skewness, kurtosis and minimum and maximum amount of rainfall.



(Source: Department of Irrigation and Drainage Malaysia 2010)

Figure 2. Map of Perlis and station Abi Kampung Bahru



(Source: Department of Irrigation and Drainage Malaysia 2010)

Figure 3. Map of Johor and station Stor JPS Johor Bahru

3. Result and Discussions

Peninsular Malaysia is located between 1° and 7° north and 99° to 105° east, and comprises an area of 131587 km^2. It is composed of highland, floodplain and coastal zones. The Titiwangsa mountain range forms the backbone of the Peninsular, from southern Thailand running approximately south-southeast over a distance of 480 km and separating the eastern part from the western part (Suhaila and Jemain, 2007). Surrounding the central high regions are the coastal lowlands. The weather of Peninsular Malaysia is warm and humid all year round with temperatures ranging from 21°C to 32°C, as is characteristic for a humid tropical climate. The precipitation climate is 20 characterized by two rainy seasons associated with the Southwest Monsoon from May to September and the Northeast Monsoon from November to March (Camerlengo and Demmler, 1997; Suhaila and Jemain, 2009). Substantial rainfall also occurs in the transitional periods (usually occur in April and October) between the monsoon seasons (Suhaila and Jemain, 2007).

During the northeast monsoon season, the exposed areas like the east coast of Peninsular Malaysia, Western Sarawak and the northeast coast of Sabah experience heavy rain spells. On the other hand, inland areas or areas which are sheltered by mountain ranges are relatively free from its influence. It is best to describe the rainfall distribution of the country according to seasons.

Rainfall events may begin or end at any time of the day. They can either occur for a few hours or extend into several days. There are three main types of rainfall: convectional rainfall, frontal or cyclonic rainfall and orographic rainfall. Convectional rainfall, associated with hot climates, mostly occurs in the tropics. It is brought about by rising and abrupt cooling of air that has been warmed by the extreme heat of the ground surface. If the air is hot enough, it rises very quickly and can cause thunderstorms. This type of rainfall is usually associated with rainfall on single wet days.

From Figure 4, the mean monthly rainfall for 2010-2012 increased compared with 1970-1972. The highest amount of rainfall is on September 2012 (23.36 mm). The maximum rainfall occurred during the south west monsoon which is from June to September and transitional period from south west monsoon to north east monsoon from October to November. Perlis is located in the northern region of Peninsular Malaysia and during the north east and south west monsoon, Malaysia receives substantial amount of rainfall all year round. However, there is a distinct peak wet season during the north east monsoon.

From Figure 5, the mean monthly rainfall for 2010-2012 is higher than 1970-1972. The highest is 17.35mm (November 2012). This is because the rainy season runs from November through March (north east monsoon), during which time the greater region of the annual rainfall is experienced. The equatorial form of climate involves a lot of rain including rainstorms during the monsoon season. During this time, the level of humidity goes up. On 2011 Johor was hit by the worst flood ever in history.

For the west coast region, April and October are predominant in the annual rainfall contribution, coincide with the intermonsoon periods. The inland region is less influenced by the intermonsoon period. The rainfall in May is contributing most of the annual rainfall, followed by November. It is noted that May and November are the beginning of the south west monsoon and north east monsoon, respectively. Thus, the monsoon conditions have a different effect on the rainfall distribution in the three regions. In general, starting in November, the rainfall maxima shift from east to west during a year.

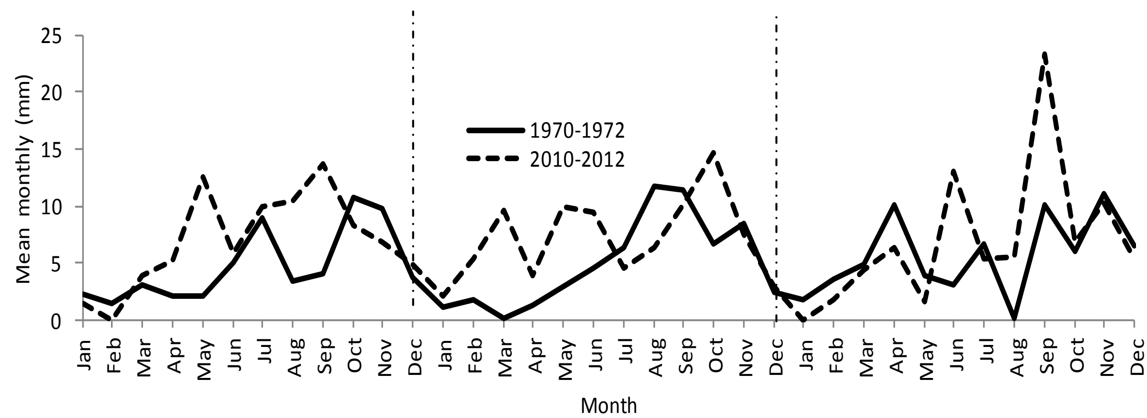


Figure 4. Graph for station Abi Kampung Bahru, Perlis

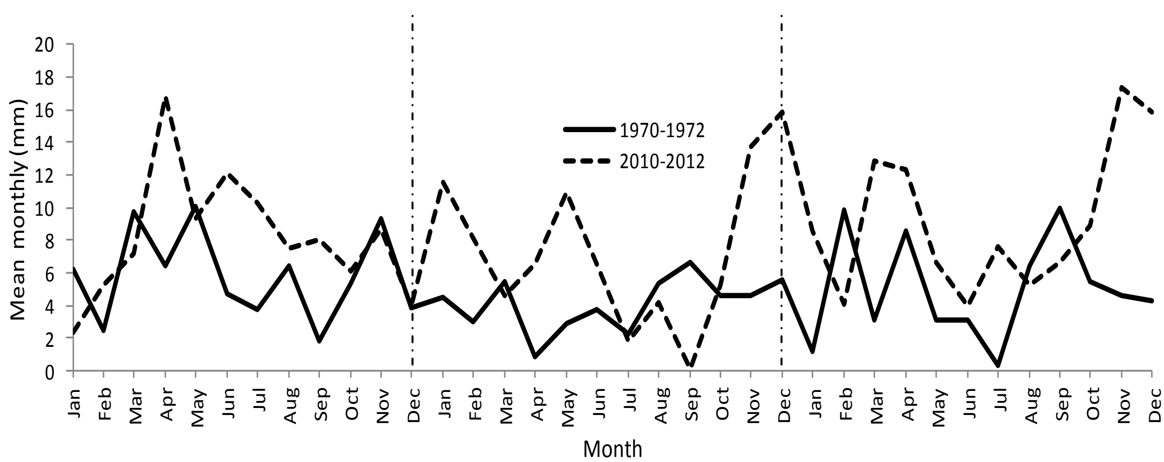


Figure 5. Graph for station Stor JPS Johor Bahru, Johor

The south west monsoon has generally lower wind speeds than the north east monsoon. Most winds during south west monsoon come to Peninsular Malaysia from Sumatra, where the high mountain ranges create rain sheltering effects for the west coast of Peninsular Malaysia. As the Strait of Malacca becomes wider towards the north, the land-sea breeze and convection become the more important and may cause regional and local differences in rainfall patterns (Oki and Musiake, 1994).

Descriptive statistics of the monthly rainfall amount for each of the two rain gauge stations are summarized in Table 1. Stor JPS, Johor Bahru station from 2010-2012 received the highest mean rainfall amount followed by station Abi Kg. Bahru from 2010-2012, 1970-1972 and Stor JPS, Johor Bahru station from 1970-2012. Station Abi Kg. Bahru, Perlis for 2010-2012 has the highest standard deviation of monthly rainfall amount. This station also has the highest standard error mean, variance, range, and maximum value of rainfall compared with others.

Table 1. Descriptive statistics for rainfall of Station Stor JPS, Johor Bahru and Station Abi Kg. Bahru

Descriptive	Stations Stor JPS, Johor Bahru, Johor		Station Abi Kg. Bahru, Perlis	
	1970-1972	2010-2012	1970-1972	2010-2012
Number of month, N	36	36	36	36
Mean (mm)	4.99	8.24	5.07	7.02
Std. Error of Mean (cm)	0.44	0.72	0.59	0.79
Median	4.66	7.54	3.92	6.04
Std. Deviation	2.62	4.30	3.53	4.72
Variance	6.88	18.51	12.46	22.31
Range	9.77	17.27	11.76	23.36
Minimum	0.33	0.08	0.03	0
Maximum	10.10	17.35	11.79	23.36

4. Conclusions

The research is to analyse the changes and comparing between the three years earlier (1970-1972) and the three latest years (2010-2012) for both stations (Abi Kg. Bahru, Perlis and Stor JPS, Johor Bahru, Johor) which represent the northern region and southern region of Peninsular Malaysia.

The characteristics of rainfall are described and analyzed based on both stations and the descriptive statistics were calculated to determine the rainfall profile. It was found that the maximum rainfall (23.36 mm) is in station Abi Kg. Bahru for 2010-2012 and the lowest rainfall is in station Stor JPS, Johor Bahru for 1970-1972. For the maximum value, it shows the highest increment (49.53%) in rainfall is for Station Abi. Kg. Bahru and 41.7% for Station Stor JPS, Johor Bahru. For mean value, Station Stor JPS, Johor Bahru recorded an increase of 39.44% compared to Station Abi Kg. Bahru (27.78%). This can be concluded that the amounts of rainfall were increasing tremendously for both stations within 30 years.

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