Rainfall Patterns Analysis over Ampangan Muda, Kedah from 2007 - 2016

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Abstract. The scientific knowledge about climate change and climate variability over Malaysia pertaining to the extreme water-related disaster such as drought and flood. A deficit or increment in precipitation occurred over the past century becomes a useful tool to understand the climate change in Malaysia. The purpose of this work is to examine the rainfall patterns over Ampangan Muda, Kedah. Daily rainfall data is acquired from Malaysian Meteorological Department to analyse the temporal and trends of the monthly and annual rainfall over the study area from 2007 to 2016. The obtained results show that the temporal and patterns of the rainfall over Ampangan Muda, Kedah is largely affected by the regional phenomena such as monsoon, El Niño Southern Oscillation (ENSO), and the Madden-Julian Oscillation. In addition, backward trajectories analysis is also used to identify the patterns for long-range of synoptic circulation over the region.

1. Introduction
Precipitation is a key input to ecohydrological and hydrological models, which is also crucial for human survival [1]. Besides, precipitation is a major component of the water cycle and is mainly affected by regional temperature [2]. Thus, a lot of studies have been carried out to study the rainfall behaviour and pattern because the long-term rainfall data is a basic to study the forecast local rainfall variability, extreme trend analysis and climate change [3]. Some findings show that decrease in rainfall such as northern China [4] and Kenya [5].

In the Southeast Asia region, the number of rainy days has decreased significantly, and the annual rainfall was found to decrease between 1961 and 1998 [6]. Meanwhile, in recent years, there have been many extreme and drought events over Malaysia [7]. Despite this, acquisition of reliable rainfall data is quite a challenging task, such as in Malaysia. Thus, ground-based gauge collection can consider as one of the best way to acquire the reliable rainfall data.

2. Study Area
Peninsular Malaysia is in Southeast Asia within the latitudes of 1° to 7° N and the longitudes of 99° to 105° E (south of Thailand, north of Singapore, and east of Sumatra). Peninsular Malaysia has an area of approximately 130,598 km² (Figure 1) and an estimated population of 23 million. The coordinate of the study area is 6° 07' N, 100° 51' E and the elevation is about 110 m. Since Peninsular Malaysia is located at the equator and it enjoys a humid tropical climate throughout the year; the weather is warm and humid, and the average temperature approximately 20 °C to 32 °C [8].

Mountainous topography and complex land-sea interactions significantly influence the tropical climate. Intra-seasonal and interannual fluctuations, such as the El Niño Southern Oscillation (ENSO), the Indian Ocean Dipole, and the Madden-Julian Oscillation, significantly influence
Malaysia’s inter-annual climate variability. The highest average temperatures start from April to May. Meanwhile November to January is the month with lowest average temperatures.

3. Methodology
Daily rainfall data from the rain gauge station at Ampangan Muda, Kedah was collected from the Malaysian Meteorological Department ((MMD) from 2007 to 2016. This station was selected with the missing data < 10% as missing data more than 20% could influence rainfall trends estimation [10]. All the rainfall data were recorded based on the automatic tipping rain gauge method and the sensitivity is about 0.5 mm/ tip [11]. The 24-h daily rainfall data were collected at 00:00 Universal Time Coordinated (UTC) or 8.00 a.m. local time.

On the other hand, the backward trajectory analysis was utilized to identify the source regions for the days in which the transport is suspected. The meteorological inputs (U and V wind components, ambient temperature, height, and the surface pressure) for the trajectory model were the National Weather Service’s National Centres for Environmental Prediction (NCEP)/GDAS data set. Recently, air trajectory models have been frequently applied and developed for numerical process to purposely examine dynamic atmospheric processes of transportation [12]. The backward trajectories were performed with the GDAS meteorological data set and at a starting time of 0000 coordinated universal time (UTC), with a total run time of 96 hours. The investigation focused on a comparative analysis to evaluate the transport pathway differences during the highest and lowest rainfall months in averaged from 2007 to 2016.

4. Results and Discussion
The temporal trend of rainfall obtained from rain gauge over Ampangan Muda, Kedah is shown in Figure 2. Figure 3 shows the monthly mean of rainfall over Ampangan Muda, Kedah from 2007 - 2016. While figure 4 shows total annual of rainfall derived from gauge over Ampangan Muda, Kedah. Peninsular Malaysia experience two pronounced seasons namely the northeast monsoon (November to February), southwest monsoon (May to August) and transitional monsoon seasons [13].

Since Malaysia is located between the Indian Ocean and Pacific Ocean, hence its climate is mainly affected by natural climate variability due to these oceans. On interannual time scales, the climate variability over Malaysia is largely affected by ENSO. The study carried out by [14] showed
that the strong influence of ENSO in Malaysian rainfall is mainly caused by anti-cyclonic circulation over the northern Borneo and the southern Philippines. Besides, the seasonal anomalous rainfall over Malaysia is also modulated by the Madden-Julian Oscillation. During December to February, the northern region of Peninsular Malaysia experiences drought due to deficit of precipitation [15]. From figure 3, the monthly mean rainfall over study area showed the lowest rate of the rainfall from 2007 to 2016 during January to March. In 2007, the highest amount of total rainfall was recorded over the study area, approximately 2993.6 mm. Inversely, in 2016, the lowest amount of total rainfall was recorded over the study area, which was about 2040.8 mm.

Figure 2. Temporal trend of rainfall (monthly averaged in mm) over Ampangan Muda, Kedah.

Figure 3. Monthly mean of rainfall over Ampangan Muda, Kedah from 2007 – 2016.
Meanwhile, the backward trajectories analysis was developed by the National Oceanic and Atmospheric Administration (NOAA) Air Resource Laboratory, the HYSPLIT_4.9 model [16] were used to identify the source regions for the days in which the days experienced the highest and lowest rainfall amount. Figures 5 and 6 show the selected months which are the highest and lowest rainfall months in averaged from 2007 to 2016 for the backward trajectories analysis. Basically, during October, Peninsular Malaysia experiences transitional monsoon, strong pulses of wind in the form of cold surge penetrates to the most southern region of the South China Sea, include Malaysia. Thus, the Inter-tropical Convergence Zone (ITCZ) is located close to the equator and caused Peninsular Malaysia wetter as compare to southwest monsoon season.

Figure 5. Four-day backward trajectories during the end of October 2013 at Ampangan Muda, Kedah at 500 to 3000 m levels.
5. Conclusion
Temporal and trends of rainfall analysis have been accessed in Ampangan Muda, Kedah for the period 2007 to 2016. The monthly mean of rainfall over the study area indicated that the atmospheric circulations such as ENSO and Madden-Julian Oscillation influence the rainfall in Malaysia. Future study will focus on the relationship between extreme precipitation event and atmospheric circulation based on the historical hydro-meteorological drought evaluation.

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