Long-term trends of diurnal rainfall and hydrometeorological disaster in the new capital city of Indonesia

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Abstract. Understanding how extremes are changing in long-term rainfall conditions is an important first step for planning appropriate adaptation measures of climate change. The purpose of this study is to investigate an uneven precipitation distribution and hydrometeorological events through the long-term trend of precipitation in Penajam Paser Utara, the new capital city of Indonesia. We used gridded precipitation APHRODITE and Mann-Kendall trend test over 60 years (1954-2015). The results showed the number of consecutive wet days (CWD) is higher than consecutive dry days (CDD). It also makes the number of floods larger than the drought. Even, the trend of rainfall was decreased from 1990 to 2015.

1. Introduction
Precipitation is a main hydrological cycle parameter and is a hallmark of Earth's climate change. For variables of meteorology. Precipitation was affecting human life directly and significantly, with significant impacts on society and the environment [1]. In the last decades, previous studies showed that global climate change causes anthropogenic activities that affected the increase of extreme precipitation events encompasses the frequency and intensity [2]. The studies of extreme precipitation events have grown rapidly in Southeast Asia. As the tropics climate the trends of precipitation intensity on wet days were increased in many areas [3]. For example, the intensity and frequency of the diurnal precipitation events were significantly increased from 1951-2010 in the Philippines country [4]. In Indonesia, the researchers who examined the diurnal extreme precipitation events only work for the Jakarta area for 130 years of diurnal extreme precipitation [5].

Based on the above, the first and foremost should know is the analysis of extreme precipitation, which has to know the difference between the detection and attribution of a change to several identifiable climate factors [6]. In addition, the previous study showed that the pattern of atmospheric circulation was related to extreme precipitation events [7]. In this study, the analysis of extreme precipitation will be focused to the new capital city of Indonesia, where, the studies of trend and changes of extreme precipitation events is quite new and important to do. The purpose of this study is to investigate an uneven precipitation distribution and hydrometeorological events through the long-term trend of precipitation in Penajam Paser Utara, the new capital city of Indonesia. In addition, the assessments of extreme precipitation are needed to support the process of decision making, which has related to adaptation and mitigation strategy for disaster, water resources, and agricultural sector in the climate change phenomenon [8].
2. Methodology and data analysis

2.1. Diurnal data and precipitation indices
Penajam Paser Utara is Indonesia's new capital city, where, located in East Kalimantan and the Southern Hemisphere (approximately, 0°S–115°S). The APHRODITE dataset with 0.25° grids for 1954-2015 periods was used in this study. This dataset provides information about precipitation and temperature [9]. Based on fifty (50) climate change indices by World Meteorological Organization - Commission for Climatology (WMO–CCL), we used 8 climate change indices of precipitation extremes and processed them using the ETCCDI RClmDex software [10].

| Table 1. Extreme precipitation indices using ETCCDI. |
|-----------------------------------------------|
| Index          | Definitions / Units                                                        |
| PRCPTOT        | Annual rainfall total with RR ≥ 1 mm (mm)                                   |
| r10mm          | Annual counts of days when PRCP ≥ 10 mm (Days)                             |
| r20mm          | Annual counts of days when PRCP ≥ 20 mm (Days)                             |
| RX5day         | Annual maximum of consecutive 5-day precipitation (mm)                      |
| R95p           | Annual rainfall total of RR > 95th percentile (mm)                         |
| R99p           | Annual rainfall total of RR > 99th percentile (mm)                         |
| CDD            | Maximum number of consecutive days with RR < 1 mm (Days)                   |
| CWD            | Maximum number of consecutive days with RR ≥ 1 mm (Days)                   |

Noted. RR ≥ 1 mm is rainy days and RR < 1 mm is dry days

Table 1 provides an overview of eight (8) precipitation indices. In this study, The PRCPTOT index was defined as the total of precipitation and calculated for the rainy and dry seasons. The methodology uses bootstrap to compute values for the baseline period so that there are no discontinuities in the index time series at the beginning or end of the base for very wet days (R95p) and very wet days (R99p) extreme precipitation indices [11]. In addition, R10 (number of days with rainfall ≥ 10 mm) was used to analysis the intensity and frequency of heavy precipitation events in tropical climates. Lastly, consecutive dry days (CDD) and wet days (CWD) was analysed to know the length of the driest and wettest in a year.

2.2. Trend analysis
The RHtestsV3 software as the homogeneity test regression was used to assess the shifts of significant artificial [12]. Daily temperature quality control is carried out and its homogeneity is also tested prior to the extreme temperature indices. These indices have been assessing for years in which missing data is less than 2%. The magnitude of the seasonal trend was estimated using the linear regression method, with the statistical analysis using the Mann-Kendall nonparametric test for assessing trends in environmental time series data. The Sen Slope method was used to estimate the actual slope of the trend of climate data. In this study, the level of statistical significance is α = 0.05 with the Z value as the trend detected was used as shown in Table 2.

| Table 2. The Z value as the trend detected at a significant level of α= 0.05. |
|-----------------------------------------------|
| Z         | Trend detected                     |
| Z > 1.96  | Significant increase               |
| 0 < Z ≤ 1.96 | Insignificant increase         |
| -1.96 ≤ Z < 0 | Insignificant decrease     |
| Z < -1.96 | Significant decrease              |

2.3. SPI analysis
According to McKee et al. [13], SPI was used for quantifying dry and wet spells of monthly precipitation in the long-term periods. Besides, SPI was calculated through two (2) steps encompasses (a) fitting the long-term precipitation data into distribution of probability and (b) makes
the average of SPI for the location and desired period is zero (0) by transformed into a normal distribution. In this study, we used the SPEI packages in RStudio Software for analysing the SPI 1, 3, 12, and 24 months and classified them as shown in Table 3.

Table 3. The Floods and drought classification on SPI indices [13].

| SPI values | Classification          |
|------------|-------------------------|
| ≥ 2        | Extremely floods        |
| 1.50 to 1.99 | Severe floods        |
| 1.00 to 1.49 | Moderate floods    |
| -0.99 to 0.99 | Normal            |
| -1.00 to -1.49 | Moderate drought  |
| -1.50 to -1.99 | Severe drought    |
| < -2       | Extreme drought        |

3. Results and discussions

3.1. Rainfall trend and indices
Penajam Paser Utara has a total annual rainfall average of approximately 120 mm over 60 years. In this study, the rainy season comes from December, January, February (DJF) when most of the precipitation falls. Dry seasons occur in June, July, and August when precipitation was declined continuously. The precipitation indices were calculated encompasses r10mm, r20mm, CDD and CWD as shown in Figure 1.

![Figure 1](image_url)

Figure 1. Trends for number of days on precipitation indices.

The trend of precipitation decreased significantly, where, the Z value less than -1.96 for all seasons as shown in Figure 2 with the PRCPTOT decreased and the CDD increased starts from 1990 to 2015. In addition, some of the trends CDD is derived from very low values in 1999. Analysis of high precipitation (R95p and R99p) was decreased at Penajam Paser Utara. Although the length of CWD was increasing. These results are still limited, requiring an analysis of climate change from other factors such as human activity and urbanization to the new capital city of Indonesia, where, the extreme condition getting more attention than the average condition in the human life and natural environment.
Figure 2. Annual anomalies (mm) from 1954 to 2015 with the different precipitation indices.
3.2. SPI trend
Climatological, meteorological, and hydrological are a group of natural disasters should be considered in adaptation and mitigation strategies. Understanding the characteristics, frequency, and long-term data of the natural disasters in that area are needed. According to Yang and Liu [14], drought is classified into a climatological and meteorological disaster; floods are classified into a hydrological disaster, which has tidal, river, and flash floods.

The result showed that the evaluation of SPI trends in annual scales using the MK test is a significant decrease, which means the trend was increasing in the dryness condition for Penajam Paser Utara. Nevertheless, even the SPI trend was a significant decrease over 60 years, the number of floods event was higher than drought as showed in Figure 3. The conditions affected by the duration of diurnal rainfall was longer than after anomalies, around 1990 to 2015.

According to Seiler et al [15], SPI values represent the total precipitation with gamma standardization transformed, which has equal to zero or no deviation from the mean precipitation value in SPI time scale was chosen. The SPI time scale encompasses SPI 1-month, SPI 3-months, SPI 12-months, and SPI 24-months.

Figure 4 showed the drought and floods temporal variation in the different SPI time scales for Penajam Paser Utara. The result showed that the SPI 1 and 3 has a floods frequency is higher compared to the longer timescales; it takes a shorter time (at most 1 month). In addition, based on SPI 1 analysis, Penajam Paser Utara has wet conditions periods in the different categories with the range from moderate (78 months), severe (34 months), and extreme (9 months) over 60 years.

4. Conclusion
The trend of diurnal precipitation in the Penajam Paser Utara as the new capital city of Indonesia shows a decreased trend after 1993–2014. It makes the extreme drought condition higher than floods hazard. In addition, the extreme precipitation indices with the CWD indices were higher than the CDD indices. It also makes the number of floods larger than the drought. Even, the trend of rainfall was decreased from 1990 to 2015.
Figure 4. The temporal variation of SPI-1, 3, 12, and 24 in the Penajam Paser Utara

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