CHIRPS SATELLITE RAINFALL PRODUCT REPRESENTING RAINFALL TREND AND VARIABILITY OVER THAILAND

Pramet Kaewmesri[1], Pakorn Petchprayoon[1], Nuntikorn Kitratporn[1], Kulapach Lhapawong[1], Vinitar Khettar[1]
[1]Geo-Informatics and Space Technology Development Agency (GISTDA), Bangkok, Thailand,
Email: pramet.kae@gistda.or.th, pakorn@gistda.or.th, nuntikorn.kit@gistda.or.th, kulapach@gistda.or.th, vinitar@gistda.or.th,

KEY WORDS: CHIRPS, rainfall, linear regression analysis, Thailand

ABSTRACT: The objective of this study used data from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) global gridded data observation to statistical analysis rainfall over the Thailand (from 1981 to 2020 (40 years period)) with a domain of 0.05° by 0.05° grid spacing. The central tendency (mean, range, etc.) and dispersion (S.D, Kurtosis, etc.) were used in the statistical analysis. For identifying the trend in the rainfall data, the statistical analysis of linear regression was used in this study. The results in this study were shown the total amount of rainfall changes over three periods that were period I (1981-1990), period II (1991-2000), period III (2001- 2010) and period IV (2011-2020). In the basic statistical was analyzed rainfall annual, rainfall monthly, and regression monthly rainfall analysis over Thailand. In basic statistical was shown the highest annual mean rainfall was 2011, which recorded an amount of 184.800 mm. The record indicated the standard deviation correlating the highest annual mean rainfall was 135.500 mm. From the results of the linear regression analysis revealed downward trends in the rainfall for the months of February and November and upward trend for other months.

1. INTRODUCTION

Thailand is located in the tropical area close to the equator at longitudes 97°22′ East to 105°37′ East and latitudes 97°22′ North to 97°22′ North. The climate of Thailand is under the influence of the seasonal monsoon wind. The seasons in Thailand can be divided into three seasons, according to the climate pattern and meteorological conditions. The summer season (with hot dry weather) occurs during the middle of February to the middle of May. The weather becomes warmer, especially in the Northern and Northeastern area of Thailand. The winter season (with dry weather) occurs during the middle of October to the middle of February. This season is influence by the Northeast monsoon. Therefore, this period of the year is cold during December to January. Sometime there is a great amount of rainfall in the Southern part of Thailand during November. The rainy season (with hot wet weather) occurs during the middle of May to the middle of October. The Southwest monsoon prevails over Thailand and substantial occurs over Thailand (Kaewmesri et al. 2017, Sooktawee et al. 2014).

Over Thailand, the agriculture is the leading branch of regional economy. In general, the climate factor is main of important natural part of agriculture. Another reason, because the background of climate change and climate variability are more impact over this area especially important for sustainable development of the economic power engineering, agriculture area, runoff water, etc.

For example, several extreme over Thailand (Figure 1), the heavy rainfall events have been reported over the country in Thailand.

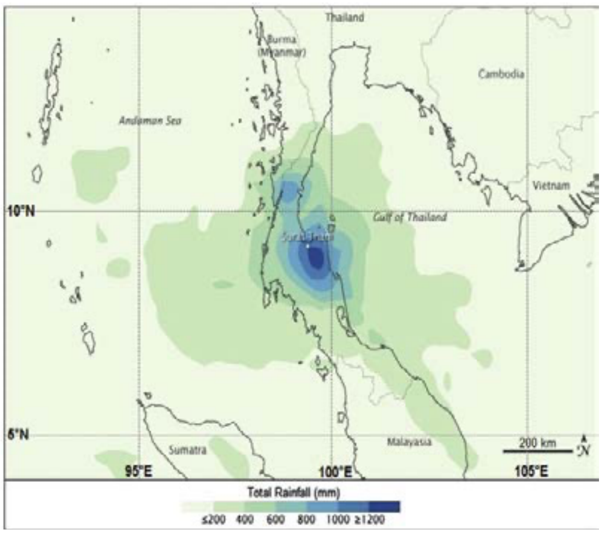

Figure 1 The accumulate rainfall of March 23-30, 2011 resulting in a heavy flooding event (Loo Y et al. 2015).

The extreme rainfall case occurred on March 23-30, 2011 caused severe big flooding over east of southern Thailand. The accumulated rainfall rage from 200 mm to 1,200 mm across the east of southern Thailand with the Malaysia Peninsula. Surat Thani province in the east of southern Thailand was recorded the most rainfall immediately by NASA. The flooding in this event was affected by 842,324 people, 8 provinces and killing 13 people (Humphries et al. 2018, Loo Y et al. 2015). The rainfall behavior can be change possibly due to climate change. So, the extreme event has increasingly important in analyzing the rainfall.

However, the understanding the mechanism of long-term climate over Thailand has been important and interested. In this research, the statistical analysis examined historical long-term climates on Thailand. If understanding mechanism climate through statistical analysis that can help the risk assessment policies for increasing demands from agricultural, industrial, and domestic sectors over Thailand.

2. METHODOLOGY

2.1 Study area

The Thailand region is located at a longitude 97°22′ East to 105°37′ East and latitudes 97°22′ North to 97°22′ as shown in Figure 2.

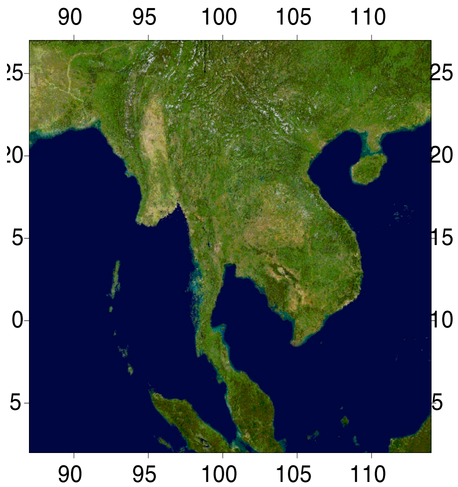

Figure 2 Domain of study area (Thailand).

The climate of Thailand is under the influence of monsoon winds of seasonal character that is pre`-monsoon, southwest monsoon, and northeast monsoon. The pre-monsoon starts period from March to April every year. This monsoon is transitional period from Northeast to Southwest monsoon. This period, the weather has warmer especially North and Northeast of Thailand. The Southwest monsoon which starts in May to October that brings a stream of warm moist air from the Indian Ocean towards Thailand causing abundant rain over the country, especially the windward side of the mountains.

Over Thailand, the rainfall is not only occurred by the Southwest Monsoon. Furthermore, the Inter Tropical Convergence Zone (ITCZ) and tropical cyclones produce a large amount of rainfall over Thailand. The Northeast monsoon start period from November to February. This period, the wind brings the cold and dry air from anticyclone from the South China Sea (SCS) and China mainland. It causes mild weather and abundant rainfall along the eastern coast of Thailand and Southern Thailand

The observation data from CHIRPS, in particular basic characteristics of rainfall, their monthly, were used for establishment of atmospheric rainfall dynamics in Thailand. Data of observation over atmospheric rainfall obtained from the following gridded point and used for study over Thailand during 1981-2020.

2.2 Rainfall satellite observation data

CHIRPS is a relatively new land-only climatic database of precipitation, available since early 2014, which uses three types of information: global climatology, satellite estimates and in situ observations. It incorporates: a monthly precipitation climatology CHPClim (Climate Hazards Group Precipitation Climatology), quasi-global geostationary thermal infrared satellite observation (TRMM 3B42 version 7), atmospheric model rainfall fields CFS (Climate Forecast System) from NOAA and precipitation observation from various sources including national or regional meteorological services (Funk et al. 2014). Nevertheless, the key difference with all other existing precipitation databases has a spatial resolution of 0.5 or lower (Tapiador et al. 2012), while a mere few of them like TRMM's 3B42 (Huffman et al. 2007) and E-OBS (Haylock et al. 2008) have a 0.25 resolution. CHIRPS data are recently available on daily temporal resolution making it a unique database in such high resolution (e.g., 5 km) with quasi-global coverage, with principal objective monitoring drought and environmental change over land, and also making available recent climate extremes. At the same time, it is very temping to study the performance of such a database, especially over small areas.

2.3 Statistical analysis

The statistical analysis was used to determine the measure in this study that includes mean, median, S.D., kurtosis, skewness, min, max, range and linear regression. For identifying the trend in the rainfall data, the statistical analysis of linear regression was used.

Linear regression is one of the simplest methods to calculate the trend of data in the time series (Humphries et al. 2018, Nyatuame et al. 2014). The equation of the linear regression line is written by

$$Y = a + bX, \quad (1)$$

While Y is the dependent variable. X is the independent variable. The slope line is b and a is the intercept (value of Y when $X = 0$). The slop line has described the trend of rainfall. If slope line is positive that means rainfall increase trend. But if the slope line is negative that means rainfall decrease trend. In this study the dependent variable Y is rainfall and the independent variable X is year. The linear regression requires the assumption of normal distribution. In this study, the null hypothesis is that the slope of the line. is zero or there is no trend in the data. The probability (P value) was shown the significance level $\alpha = 0.05$.

The value of R-square (R^2) or the square of the correlation from the regression analysis was used to show relationship between the variable X and Y. The value is a fraction between 0.0 and 1.0 . A R-square (R^2) value if 1.0 mean that the correlation becomes strong, and all point lie on a straight line. On the other hand, a R-square (R^2) value if 0.0 means that there is no correlation and no linear relationship between X and Y.

3. RESULTS AND DISCUSSION

For determination of rainfall change this study use 1981 – 2020 observation data, which were separated in to 10-years during 1981 -1990 periods, 10 -years in 1991-2000 periods, 10-years in the 2001-2010 periods, and 10-years in 2011-2020. Consider analysis shows that under the influence of global climate change and variability in Thailand, from 1981-2020 (almost 40-year periods) total amount of rainfall experiences the following changes: during the period rainfall amount varies from 13.499 mm to 330.021 mm (Fig.3).

In the period I (during 1981-1990), the total amount of rainfall changes from 13.499 mm to 308.545 mm. The rainfall changes from 38.877 mm to 84.680 mm (in Pre-monsoon), change from 192.097 mm to 308.545 mm (in Southwest monsoon), and changes from 13.499 mm to 92.666 mm (in Northeast monsoon).

In the period II (during 1991-2000), the total amount of rainfall changes from 17.237 mm to 325.609 mm. The rainfall changes from 22.956 mm to 88.825 mm (in pre-monsoon), change from 167.208 mm to 325.609 mm (in Southwest monsoon), and changes from 17.237 mm to 78.881 mm (in Northeast monsoon).

In the period III (during 2001-2010), this period is shown more validate and the highest rainfall (242.920 mm) than another period (period I: 222.510 mm, period II: 219.707 mm, period IV: 219.345 mm) in May. The total amount of rainfall changes from 21.130 mm to 97.411 mm (in Pre-monsoon), change from 182.207 mm to 317.809 mm (in Southwest monsoon), and changes from 19.846 mm to 77.195 mm (in Northeast monsoon).

In the period IV (during 2011 - 2020), this period is shown more validate and highest rainfall in January, July, and August. In January was highest rainfall (32.853 mm) than another period (period I: 13.499 mm, period II: 17.237 mm, and period III: 18.846 mm). In July was highest rainfall (330.021 mm) than another period (period I: 285.077 mm, period II: 308.116 mm, and period III: 317.809mm). In August was highest rainfall (328.995 mm) than another period (period I: 308.545 mm, period II:325.609 mm, and period III: 322.499 mm). The total amount of rainfall changes from 32.853 mm to 87.708 mm (in Pre-monsoon), change from 180.472 mm to 330.021 mm (in Southwest monsoon), and changes from 32.853 mm to 87.708 mm (in Northeast monsoon)

However, the trend of all periods was shown similarly rainfall trend. The rainfall trend was shown the minimum trend on period I, period II, and period III that was record in January. But on period IV was record in February. While the maximum trend was record in August with period I, period II, and period III. But on period IV was record in July. In the mentions period, according to data on rainfall (1981-2020) during 40-year periods is observed the change rainfall amount according to periods (during the period I to IV period). During the period I and II, the annual of rainfall increased by 2.893 mm, from period II to period III increased by 8.361 mm, from period III to IV period decreased by 0.275 mm. In general, for 40 years, the rainfall is increased 10.980 mm (Fig 4).

Materials of observation over the annual rainfall amount in the course of years (1981-2020) are presented in Fig 5. The maximum rainfall was recorded in 2011 (184.800 mm), and the second maximum was recorded in 2017 (182.848 mm), and the third maximum rainfall was recorded in 1994 (176.210 mm). While the minimum rainfall was recorded in 1992 (137.736 mm), the second minimum was recorded in 1993 (141.004 mm), and the third minimum was recorded in 1987 (141.607 mm).

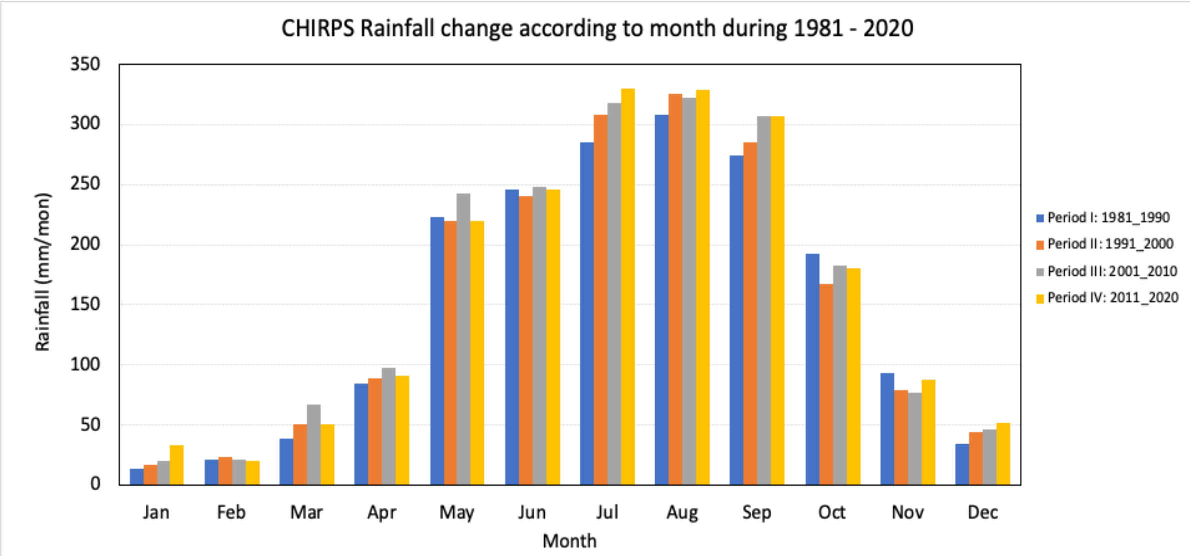

Figure 3 Rainfall means for each period according to a month in 40 years from 1981 to 2020 over Thailand

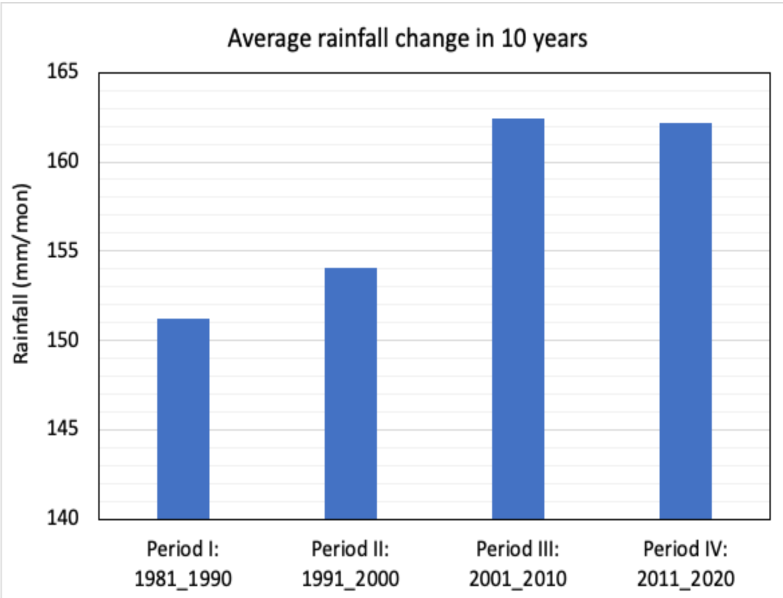

Figure 4 Average rainfall in 10-year period from 1981 to 2020 over Thailand

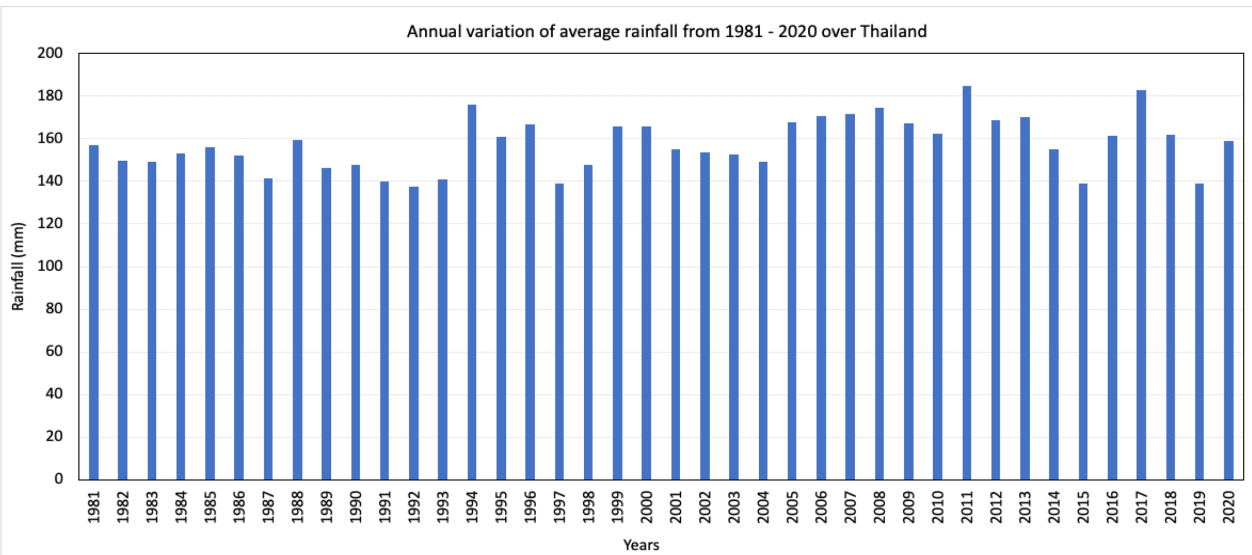

Figure 5 An annual variation of rainfall average from 1981 to 2020 (40 years) over Thailand.

From Table 1, the year with the year with the highest annual average rainfall was 2011, which recorded an amount of 184.800 mm. The record indicated the standard deviation (S.D.) correlating the high annual mean rainfall was 135.500 mm. The high standard deviation value can be easily correlated with the high rainfall rage. The rainfall rage signifies the difference between the maximum and minimum annual rainfall.

Skewness is a measure of symmetry or, more precisely, the lack of symmetry. The data set is said to be symmetric if it looks the same to the left and right from the center point. The skewness for a normal distribution is zero, and any symmetric data should have skewness indicate that data are skewed to the left and positive values for the skewness indicate that data are skewed to the right.

Kurtosis is a measure of data flatness relative to a normal distribution. That is, data sets with high kurtosis tend to have a district peak near the mean, decline rather rapidly, and have a heavy tail. Data sets with low kurtosis tend to have a flat top near the mean rather than a sharp peak. The standard normal distribution has a kurtosis of zero. Positive kurtosis indicates a peaked distribution and negative kurtosis indicates a flat distribution.

Table. 1 Descriptive basic statistical method of rainfall annual over Thailand.

Year	Annual	Average	Median	S.D.	Kurtosis	Skewness	Min	Max	Range
1981	1881.720	156.810	159.462	115.683	-1.775	0.008	11.780	321.930	310.150
1982	1794.358	149.530	123.421	119.718	-1.558	0.356	7.434	324.121	316.687
1983	1791.117	149.260	143.562	122.975	-1.737	0.186	11.817	342.330	330.513
1984	1835.451	152.954	142.448	114.266	-1.631	0.292	20.172	334.683	314.511
1985	1874.261	156.188	145.896	112.055	-1.819	0.086	11.907	299.719	287.812
1986	1825.531	152.128	146.725	120.926	-1.913	0.078	11.776	311.293	299.517
1987	1699.285	141.607	133.080	111.186	-1.322	0.370	12.454	323.251	310.797
1988	1913.014	159.418	169.427	116.427	-2.050	-0.109	14.941	297.937	282.996
1989	1757.323	146.444	135.950	120.319	-1.989	0.112	11.836	306.447	294.611
1990	1770.590	147.549	152.967	110.557	-2.122	-0.020	14.093	278.129	264.036
1991	1681.519	140.127	113.445	118.486	-1.107	0.507	14.444	361.338	346.894
1992	1652.837	137.736	106.279	121.962	-1.641	0.407	12.950	323.580	310.630
1993	1692.005	141.000	117.197	106.573	-1.608	0.301	13.171	300.966	287.795
1994	2114.523	176.210	119.129	143.344	-1.798	0.318	10.191	392.606	382.415
1995	1930.892	160.908	131.706	135.494	-1.241	0.533	17.854	379.045	361.191
1996	1999.570	166.631	152.822	123.210	-1.170	0.300	12.170	376.535	364.365
1997	1667.555	138.963	119.344	117.247	-0.785	0.717	7.765	340.488	332.723
1998	1772.912	147.743	131.270	115.150	-1.799	0.207	13.248	310.022	296.774
1999	1988.439	165.703	167.653	110.859	-1.942	-0.023	22.990	307.780	284.790
2000	1989.674	165.806	179.617	108.754	-1.946	-0.115	20.523	295.123	274.600
2001	1858.244	154.854	169.171	107.488	-1.794	0.008	18.221	317.750	299.529
2002	1843.690	153.641	127.895	118.455	-1.357	0.368	11.319	338.747	327.428
2003	1831.738	152.645	131.693	118.124	-1.705	0.296	14.113	319.084	304.971
2004	1790.229	149.186	92.945	128.239	-2.043	0.322	17.281	333.225	315.944
2005	2013.505	167.792	140.139	130.961	-1.370	0.374	12.090	372.354	360.264
2006	2047.508	170.626	163.569	133.229	-1.404	0.319	17.705	375.222	357.517
2007	2057.781	171.482	173.256	131.293	-2.072	0.047	16.096	324.364	308.268
2008	2092.311	174.359	174.775	117.586	-1.824	-0.068	21.367	331.610	310.243
2009	2007.526	167.294	153.111	120.735	-1.701	0.075	18.144	341.405	323.261
2010	1950.708	162.559	123.351	131.903	-1.093	0.531	18.217	403.638	385.421
2011	2217.604	184.800	155.859	135.500	-1.744	0.219	18.625	369.331	350.706
2012	2022.571	168.548	123.871	115.919	-1.717	0.372	27.431	334.331	306.900
2013	2043.062	170.255	143.869	133.954	-1.573	0.402	23.574	372.467	348.893
2014	1862.630	155.219	132.583	122.592	-1.412	0.327	9.884	343.429	333.545
2015	1667.497	138.958	121.108	109.053	-1.504	0.386	14.214	294.296	280.082
2016	1935.485	161.290	152.070	126.173	-1.926	0.100	14.954	332.524	317.570
2017	2194.177	182.848	162.223	128.795	-1.132	0.448	21.248	415.332	394.084
2018	1941.353	161.779	135.622	117.694	-0.989	0.519	24.277	382.507	358.230
2019	1665.653	138.804	98.047	122.974	0.206	0.892	18.373	406.672	388.299
2020	1910.169	159.181	136.546	125.182	-1.769	0.202	9.825	336.569	326.744

Table 2 clearly revealed that July had the highest Standard deviation. The highest amount of average monthly rainfall was recorded in August (321.412 mm) and contributed to 17.009 % of annual rainfall, followed by July (310.256 mm) and September (293.467 mm) with contributed to 16.419% and 15.530% respectively. The lowest was recorded in January (20.859) and contribute to 1.104% of annual rainfall, followed by February (21.563) and March (51.686 mm) with contributed to 1.141% and 2.735% respectively.

Table 2 Descriptive basic statistical method of monthly rainfall over Thailand

Month	Annual	Average	Median	S.D.	Kurtosis	Skewness	Min	Max	Rage
Jan	834.350	20.859	16.398	14.022	6.280	2.329	7.434	76.930	69.495
Feb	862.491	21.562	19.882	7.513	-0.770	0.440	9.884	37.740	27.856
Mar	2067.446	51.686	44.902	28.836	1.884	1.398	12.950	140.965	128.015
Apr	3618.333	90.458	86.967	30.448	-0.294	0.438	33.676	162.608	128.932
May	9044.812	226.120	214.616	45.534	-0.891	0.285	154.549	318.152	163.603
Jun	9803.852	245.096	242.360	26.547	0.378	-0.038	174.674	303.496	128.822
Jul	12410.227	310.256	308.841	42.744	-0.154	0.236	218.707	415.332	196.625
Aug	12856.470	321.412	312.441	33.983	0.465	1.018	276.816	406.672	129.856
Sep	11738.667	293.467	286.581	37.247	-0.400	0.555	236.544	376.535	139.991
Oct	7219.835	180.496	178.437	35.731	-0.154	0.322	103.805	260.717	156.912
Nov	3364.497	84.112	85.407	25.892	-1.017	0.230	42.159	137.834	95.675
Dec	1765.036	44.126	40.960	16.233	-0.213	0.440	13.223	84.131	70.908

The results of the linear regression trend analysis of Thailand are presented in Table 3. The trend of rainfall from January to December for 40 years. This calculation has been computed for each month independently. Table 3 revealed downward trends in the rainfall for the months of February and November and upward trend for other months. The R square statistic also indicated a very weak relationship between the variables, rainfall, and year.

In future work, the research will plan to analyst probability value (P value) from the regression analysis for the slopes of the monthly trend lines will greater than the significant level $\alpha = 0.05$, the null hypothesis (H_0: there is no significant difference in the mean annual rainfall among the climate zone in Thailand of 40 years). That means there is no statistically significant trend in monthly rainfall data for Thailand

Table 3 Regression monthly rainfall analysis over Thailand

Month	Regression	R square
Jan	Y = 0.5813X + 8.9412	0.235
Feb	Y = -0.038X + 22.36	0.004
Mar	Y = 0.3709X + 44.083	0.023
Apr	Y = 0.4253X + 81.739	0.027
May	Y = 0.2421X + 221.16	0.004
Jun	Y = 0.0406X + 244.26	0.000
Jul	Y = 1.3352X + 282.88	0.133
Aug	Y = 0.5077X + 311	0.031
Sep	Y = 0.9701X + 273.58	0.093
Oct	Y = 0.0727X + 179.01	0.000
Nov	Y = -0.1137X + 86.442	0.003
Dec	Y = 0.5141X + 33.586	0.137

4. CONCLUSION

This study was considered analysis shows that under the influence of global climate change and variability in Thailand, from 1981-2020 (almost 40-year period). In period I (during 1981-1990), the total amount of rainfall changes from 13.499 mm to 308.545 mm. In period II (1991-2000), the total amount of rainfall changes from 17.237 mm to 325.609 mm. In the period III (during 2001-2010), The total amount of rainfall changes from 19.856 mm to 322.499 mm. This period is shown more validate and the highest rainfall (242.920 mm) than another period (period I: 222.510 mm, period II: 219.707 mm, period IV: 219.345 mm) in May. In the period IV (during 2011 - 2020), The total amount of rainfall changes from 19.856 mm to 322.499 mm. This period is shown more validate and highest rainfall in January, July, and August. In January was highest rainfall (32.853 mm) than another period (period I: 13.499 mm, period II: 17.237 mm, and period III: 18.846 mm). In July was highest rainfall (330.021 mm) than another period (period I: 285.077 mm, period II: 308.116 mm, and period III: 317.809mm). In August was highest rainfall (328.995 mm) than another period (period I: 308.545 mm, period II:325.609 mm, and period III: 322.499 mm). In the basic statistical was shown the highest annual average rainfall was 2011, which recorded an amount of 184.800 mm. The record indicated the standard deviation (S.D.) correlating the high annual mean rainfall was 135.500 mm. From the linear regression trend of rainfall from January to December for 40 years. This calculation has been computed for each month independently. The downward trends in the rainfall for the months of February and November and upward trend for other months.

In future work, the research will plan to analyst probability value (P value) from the regression analysis for the slopes of the monthly trend lines will greater than the significant level $\alpha = 0.05$, the null hypothesis (H_0: there is no significant difference in the mean annual rainfall among the climate zone in Thailand of 40 years). That means there is no statistically significant trend in monthly rainfall data for Thailand

5. ACKNOWLEDGMENTS
The authors would also like to thank GISTDA for support this research. This research is funded by National Research Council of Thailand (NRCT).

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