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Evaluating Long-Term Trends in Annual and Seasonal Precipitation in Taiwan

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Abstract. This work studies long-term rainfall variations in Taiwan and provides local climate change analyses to global climate change. Around a century of rainfall data from 33 rain-gauges populate the database used herein. Statistical tests, such as cumulative deviations, Mann-Whitney-Pettitt statistics and the Kruskal-Wallis test, were first employed to determine whether annual rainfall series exhibit any regular trend. Analytical results indicate that the annual rainfall has increased in northern Taiwan, declined in central and southern Taiwan, and exhibited no clear tendency in Eastern Taiwan. Almost all of these rainfall series changed significantly around 1960, which date divides historical rainfall series into two sample groups. This change in the seasonal rainfall was further investigated.

Key words: climate change, precipitation trend analysis, cumulative deviations, Kruskal-Wallis statistics, Mann-Whitney-Pettitt test

Introduction

Continuously increasing levels of atmospheric carbon dioxide have been recorded for over five decades, resulting in global warming. This phenomenon has been reported to have increased the global average surface temperature by $0.6 \pm 0.2\,^{\circ}$C (IPCC, 2001), which increase may be responsible for climate change (including for example, changes in amounts of precipitation and storm patterns). On average, global land precipitation has increased by approximately 2% in the 20th century (IPCC, 2001).

Many investigations have been conducted to explore whether precipitation records exhibit trends. For instance, Lettenmaier *et al*. (1994) identified increases in precipitation from September to December at as many as 25% of stations in the central part of the United Sates. Kiely *et al.* (1998), Kiely (1999) and Hoppe and Kiely (1999) determined that annual precipitation increased in Ireland after 1975. Precipitation increases in March and October are significant and the stream flow data exhibit the same trend. Hennessy *et al*. (1999) found that annual total rainfall has undergone changes, increasing markedly by 14% in Victoria and increasing insignificant by 15%–18% in New South Wales, the Northern Territory and South Australia between 1910 and 1995. Serrano *et al.* (1999) applied the Mann-Kendall test to the annual and monthly series over the Iberian Peninsula. They observed a drop trend in the month of March. Lucero (1998) and Lucero and Rozas (2002) analyzed changes in the aggregation of daily rainfall and found a positive trend in the annual rainfall in central Argentina, in the southern middle-latitudes. An increase in the number of rainy days is responsible for the strong positive variation in seasonal and annual rainfall. This increase occurs during the three-month periods January–March (summer) and April–June (autumn). Timothy *et al.* (2000) observed a considerable increase ofrainfall in winter and a decrease in summer since 1960 in the UK. Collischonn *et al.* (2001) found an increase in rainfall in Paraguay since 1970. Bobba and Diiwu (2002) analyzed the hydrological and meteorological data to identify trends and estimated their magnitudes in the Northeast Pond River Watershed, Canada. The change in precipitation varied between 0.6 and 13 mm per year, and the largest upward change was in October and the greatest downward trend was in February. Yue and Hashino (2003) found that annual precipitation fell, and monthly precipitation declined considerably from September through January and in April to the side of Japan next to the Pacific. Near the southern islands of Japan both annual precipitation and monthly precipitation substantially decreased from September to February and in June and July.

As in the aforementioned works, various researchers around the world analyzed trends in precipitation in the areas of interest. As more studies are performed on climate change in various areas, global climate change becomes better understood. This work studies the variations and trends in long-term rainfall series on various time scales (annual, seasonal and monthly rainfalls) in Taiwan. These analytical results concerning local climate change and precipitation trends may help to improve our understanding of global climate change.

Data Set

Taiwan receives an annual average rainfall of 2510 mm, which is unevenly distributed spatially and temporally. About 79% of the annual precipitation falls in the wet season (from May to October), and most of this falls during storms or typhoons. Figure 1 presents the spatial distribution of these stations. The Water Resource Bureau divides Taiwan into four regions – northern, eastern, central and southern. The mean monthly rainfall distribution is plotted in Figure 2. In the south of Taiwan, 90% of the annual rainfall, the largest proportion of four regioins, falls in the wet season. The characteristics of the rainfall lead to frequent floods and droughts. The steep topography and poor reservoir capacity cause difficulty in storing water in the reservoir. Studies of precipitation trends support water resource management.

At least 80 years of historical records from 33 stations (Table I) were utilized herein. Figure 1 depicts four groups of stations in these four areas. Numerous

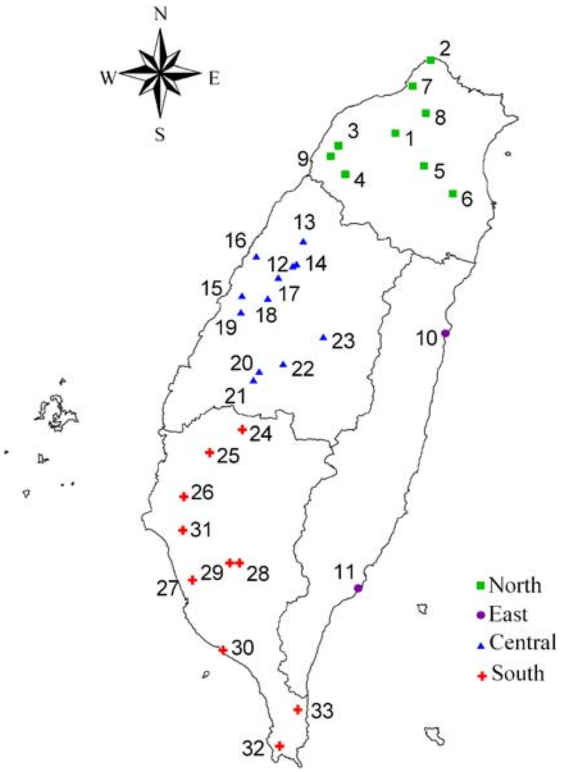


Figure 1. The spatial distribution of stations used in the study.

researchers have focused on temporal trends in annual precipitation. This work also elucidates trends in monthly and seasonal precipitations.

Analytical Methods

CUMULATIVE DEVIATIONS

A test of homogeneity of the data, the cumulative deviation test (Buishand, 1982) suggested by the World Meteorological Organization, was undertaken to verify the presence of trends in historical rainfall records. The test of homogeneity is based on the adjusted partial sums or cumulative deviations from the mean:

$$S_k = \sum_{i=1}^{k} (Y_i - \bar{Y}), \quad k = 1, K, n \tag{1}$$

where $\bar{Y}$ is the mean of the Y_i values, and n is the number of values. For a homogeneous series of records, the values of S_k fluctuate about zero. The re-scaled adjusted partial sums $S^*{}_k$ are determined by dividing the S_k values by the standard

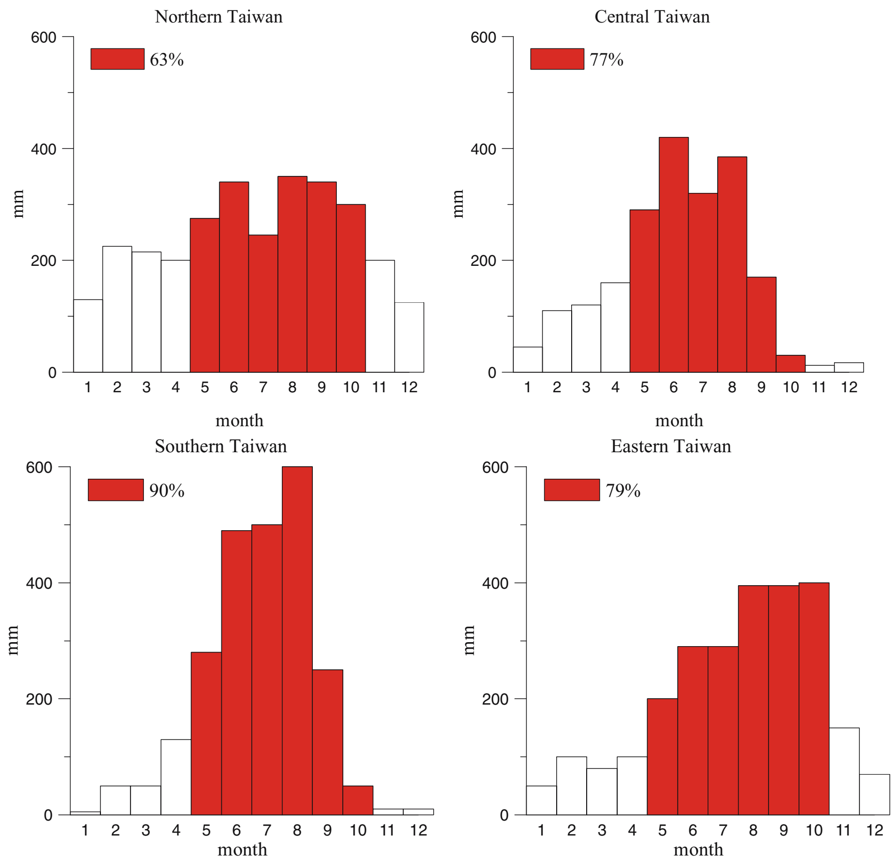


Figure 2. The mean monthly rainfall distribution in Taiwan.

deviation of the sample, as follows.

$$S_k^* = S_k / D_Y, \quad k = 1, K, n \tag{2}$$

where D_Y is the sample standard deviation and is given by

$$D_Y^2 = \sum_{i=1}^{n} (Y_i - \bar{Y})^2 / n \tag{3}$$

Based on the S_k^* values, a statistic Q, which is sensitive to departures from homogeneity, is defined as

$$Q = \max_{1 \le k \le n} \left| S_k^* \right| \tag{4}$$

Table I. Information on the raingauges used in the study

Region	Station no.	Station name	Observation Period	Leading organization	Altitude (m)
North	1	Sanhsia	1904–2001	Water Resources Agency	33
	2	Fukueichiao	1901–2001	Water Resources Agency	15
	3	Hukou work station	1904–2000	Taoyuan Irrigation Association	106
	4	Chutung	1904–2000	Hsinchu Irrigation Association	120
	5	Fushan	1914–2000	Taiwan Power Company	420
	6	Tienpi	1905–2000	Taiwan Power Company	140
	7	Tanshui	1903–2001	Central Weather Bureau	19
	8	Taipei	1897–2001	Central Weather Bureau	5
	9	Hsinchu	1901–2001	Central Weather Bureau	34
East	10	Hualien	1901–2001	Central Weather Bureau	16
	11	Taitung	1901–2001	Central Weather Bureau	9
Central	12	Cholan(2)	1904–2001	Water Resources Agency	337
	13	Tahu(1)	1904–2001	Water Resources Agency	275
	14	Cholan	1904–2001	Taichung Irrigation Association	328
	15	Tatu	1922–2001	Taichung Irrigation Association	9
	16	Tachia	1923–2000	Taichung Irrigation Association	40
	17	Fengyuan	1923–2000	Taichung Irrigation Association	210
	18	Taichung	1897–2000	Central Weather Bureau	84
	19	Changhua	1922–2000	Changhua Irrigation Association	16
	20	Erhshui	1922–2000	Changhua Irrigation Association	111
	21	Linnei(1)	1904–2001	Water Resources Agency	82
	22	Chichi	1904–2001	Yunlin Irrigation Association	234
	23	Puli	1904–2001	Nantou Irrigation Association	442
South	24	Chuchi	1904–2001	Chianan Irrigation Association	120
	25	Nanching Ranch	1916–2001	Taiwan Sugar Corporation	18
	26	Tsungyeh material	1915–1998	Taiwan Sugar Corporation	12
	27	Kangshan	1924–2000	Kaohsiung Irrigation Association	5
	28	Chungtan	1916–2000	Kaohsiung Irrigation Association	40
	29	Chishan	1904–2000	Kaohsiung Irrigation Association	46
	30	Tungkang	1904–2000	Pingtung Irrigation Association	4
	31	Tainan	1900–2000	Central Weather Bureau	8
	32	Hengchun	1900–2001	Central Weather Bureau	22
	33	Mutan	1905–2000	Water Resources Agency	320

Table II. Critical values of $Q/\sqrt{n}$.

	$Q/\sqrt{n}$		
n	90%	95%	99%
10	1.05	1.14	1.29
20	1.10	1.22	1.42
30	1.12	1.24	1.46
40	1.13	1.26	1.50
50	1.14	1.27	1.52
100	1.17	1.29	1.55
∞	1.22	1.39	1.63

(Buishand, 1982)

If the magnitude of $Q/\sqrt{n}$ exceeds the critical value of the test-statistic (Table II), then the time series is heterogeneous. Critical values of $Q/\sqrt{n}$ for the 95% confidence limits were used in this work.

MANN-WHITNEY-PETTITT STATISTIC

A non-parametric scheme developed by Pettitt (1979) can be used to determine the point of significant change in the time series. The change point in the time series of annual precipitation was determined herein using this method, which is briefly summarized as follows (Kiely *et al.* 1998; Kiely, 1999).

Let T be the length of the time series and t be the year of the most likely change point. A time series of T years of annual precipitation can be divided by the year t into two sample groups, $\{X_1, X_2, \ldots, X_t\}$ and $\{X_{t+1}, X_{t+2}, \ldots, X_T\}$. Define an index, U_t, as

$$U_t = \sum_{i=1}^{t} \sum_{j=1}^{T} \operatorname{sgn}\left(X_i - X_j\right) \tag{5}$$

where $\operatorname{sgn}(X_i - X_j) = 1$ for $(X_i - X_j) > 0$, $\operatorname{sgn}(X_i - X_j) = 0$ for $(X_i - X_j) = 0$ and $\operatorname{sgn}(X_i - X_j) = -1$ for $(X_i - X_j) < 0$.

A plot of U_t against t for a time series with no change point results in a continually increasing value of $|U_t|$. However, if a change point exists, then $|U_t|$ increases up to this change point, after which it declines. A plot with many repeated cycles of alternate increasing and decreasing $|U_t|$ demonstrates that the time series has various local change points. A means of determining the most significant change point remains an outstanding issue. Hence, this work identifies the most significant change point t that corresponds to the maximum value of $|U_t|$. Pettitt (1979) developed the following procedure to determine whether the change point is statistically significant. First, the probability that a change point is associate with maximal $|U_t|$ can be approximated by,

$$p = 1 - \exp\left[\frac{-6{K_T}^2}{T^3 + T^2}\right] \tag{6}$$

$$K_T = \max_{1 \le t \le T} |U_t| \tag{7}$$

Equations (5)–(7) yield the change point with an estimated probability of p. If p exceeds 0.75, then the change point is statistically significant.

KRUSKAL-WALLIS TEST

The significant change point can be determined using the aforementioned methods. The Kruskal-Wallis test was also employed whether a significant difference exists between the two sample groups that were separated by the change point. The procedures are as follows (Hollander and Wolfe, 1999).

1. Combine all n observations of k groups of samples and order these observations from the least to the greatest, giving them the corresponding ranks.
2. The Kruskal-Wallis statistic H is then given as follows.

   (1) If the values of the n observations vary, then value of H is,

   $$H = \frac{12}{n(n+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} - 3(n+1) \tag{8}$$

   where n_i is the size of the ith group; $n = \sum_{i=1}^{k} n_i$, and R_i is the sum of the ranks assigned to the observations of the ith group.

   (2) If some of the observations are the same, and the number of identical observations exceeds 25% of the number of samples, then H must be modified as follows.

   $$H = \frac{\frac{12}{n(n+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} - 3(n+1)}{1 - \frac{\sum_{j=1}^{c}\left(t_j^3 - t_j\right)}{n^3 - n}} \tag{9}$$

where c is the number of tied groups and t_j is the size of tied group j. When n_i exceeds five, the distribution of H is approximately the χ^2 distribution. If H exceeds $\chi^2_{(1-\alpha,k-1)}$ with $k-1$ degrees of freedom at the $1-\alpha$ confidence level, then the hypothesis of the same population is rejected. In this study, a 95% confidence level was adopted.

Table III. Change points determined by using the tests of cumulative deviations and Mann-Whiney-Pettitt statistic for each station

Region	Station no.	Change point (year)	Values of $Q\sqrt{n}$ (cumulative deviations)	Values of p (Mann-Whiney-Pettitt Statistic)
North	1	1976	0.82	0.73
	2	1943	**1.49**	**0.99**
	3	1968	0.91	**0.82**
	4	1947	0.88	**0.77**
	5	1967	**1.28**	**0.95**
	6	1966	1.08	**0.89**
	7	1946	**1.38**	**0.96**
	8	1968	**1.44**	**0.96**
	9	1966	**1.18**	**0.96**
East	10	1937	**1.41**	**0.99**
	11	1944	0.55	0.35
Central	12	1967	0.85	0.64
	13	1967	0.87	**0.82**
	14	1967	0.76	0.68
	15	1950	0.93	0.73
	16	1953	**1.38**	**0.98**
	17	1953	**1.51**	**0.99**
	18	1960	0.87	**0.81**
	19	1960	**1.73**	**0.99**
	20	1956	**2.16**	**0.99**
	21	1961	1.06	**0.90**
	22	1956	0.75	0.64
	23	1953	**1.58**	**0.98**
South	24	1953	0.74	0.71
	25	1956	**1.85**	**0.99**
	26	1956	**1.63**	**0.99**
	27	1956	**1.30**	**0.98**
	28	1953	**1.89**	**0.99**
	29	1961	**1.29**	**0.99**
	30	1961	**1.43**	**0.99**
	31	1956	**1.24**	**0.94**
	32	1961	**1.45**	**0.99**
	33	1954	**2.14**	**0.99**

Note. The number in **bold** indicates a statistically significant difference.

Table IV. Results of Kruskal-Wallis test for testing the homogeneity of annual precipitation between the two periods for each station

Region	No.	Period before change point;	Period after chang point (year)	Values of H
North	1	1904 ~ 1976	1977 ~ 2001	3.08
	2	1901 ~ 1943	1944 ~ 2001	**8.99**
	3	1904 ~ 1968	1969 ~ 2000	3.77
	4	1904 ~ 1947	1948 ~ 2000	3.01
	5	1914 ~ 1967	1968 ~ 2000	**5.95**
	6	1905 ~ 1966	1967 ~ 2000	**4.75**
	7	1903 ~ 1946	1947 ~ 2001	**6.53**
	8	1897 ~ 1968	1969 ~ 2001	**8.69**
	9	1901 ~ 1966	1967 ~ 2001	**7.32**
East	10	1901 ~ 1937	1938 ~ 2001	**9.58**
	11	1901 ~ 1944	1945 ~ 2001	0.88
Central	12	1904 ~ 1967	1968~ 2001	2.09
	13	1904 ~ 1967	1968 ~ 2001	3.56
	14	1904 ~1967	1968 ~ 2000	2.48
	15	1922 ~ 1950	1951 ~ 2000	2.90
	16	1923 ~ 1953	1954 ~ 2000	**7.86**
	17	1923 ~ 1953	1954 ~ 2000	**10.59**
	18	1897 ~ 1960	1961 ~ 2001	3.48
	19	1922 ~ 1960	1961 ~ 2000	**12.16**
	20	1922 ~ 1956	1957 ~ 2000	**4.53**
	21	1904 ~ 1961	1962 ~ 2001	**6.79**
	22	1904 ~ 1956	1957 ~ 2000	2.05
	23	1904 ~ 1953	1954 ~ 2001	**7.85**
South	24	1904 ~ 1953	1954 ~ 2001	2.50
	25	1916 ~ 1956	1957 ~ 2000	**15.04**
	26	1915 ~ 1956	1957 ~ 1998	**11.53**
	27	1924 ~ 1956	1957 ~ 2000	**7.96**
	28	1916 ~ 1953	1954 ~ 2000	**13.98**
	29	1904 ~ 1961	1962 ~ 2000	**10.44**
	30	1904 ~ 1961	1962 ~ 2000	**9.81**
	31	1900 ~ 1956	1957 ~ 2001	**6.79**
	32	1900 ~ 1961	1962 ~ 2001	**9.01**
	33	1905 ~ 1954	1955 ~ 2000	**16.34**

Note. The number in **bold** indicates a statistically significant difference.

Table V. Comparisons of mean annual precipitation between the two periods for each station

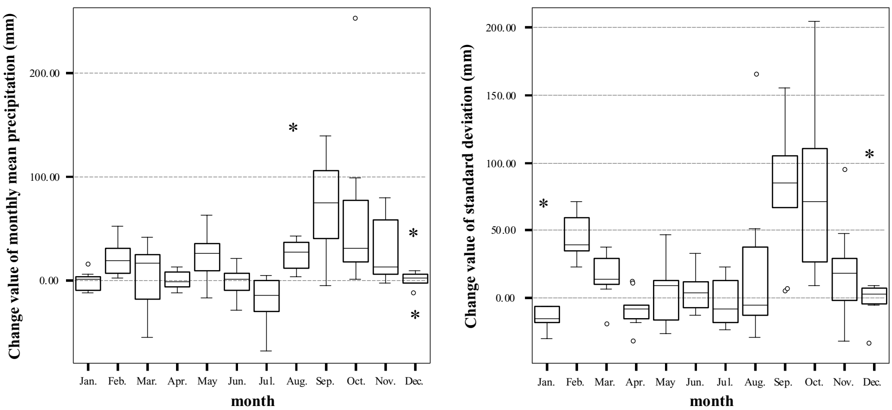
Region	Station no.	Mean annual precipitation before change point (mm)	Mean annual precipitation after change point (mm)	Change percentage (%)
North	1	2171.97	2370.07	9.12
	2	1886.74	2298.00	21.80
	3	1568.25	1753.73	11.83
	4	2133.71	1967.35	−7.80
	5	2870.34	3287.17	14.52
	6	3200.18	3605.65	12.67
	7	1896.39	2139.27	12.81
	8	2078.77	2345.68	12.84
	9	1599.11	1788.40	11.84
East	10	1912.52	2185.30	14.26
	11	1776.01	1872.17	5.41
Central	12	1868.41	2049.00	9.67
	13	1956.31	2194.80	12.19
	14	1947.25	2119.96	8.87
	15	1398.54	1212.93	−13.27
	16	1562.32	1307.09	−16.34
	17	1997.30	1712.00	−14.28
	18	1769.29	1611.68	−8.91
	19	1502.89	1217.13	−19.01
	20	2255.71	1810.64	−19.73
	21	2099.94	1894.23	−9.80
	22	2384.38	2246.37	−5.79
	23	2347.66	1998.01	−14.89
South	24	2572.26	2397.95	−6.78
	25	1882.62	1494.51	−20.62
	26	1908.07	1529.71	−19.83
	27	2019.61	1680.16	−16.81
	28	2936.59	2296.47	−21.80
	29	2519.87	2161.50	−14.22
	30	1908.54	1599.04	−16.22
	31	1847.86	1593.96	−13.74
	32	2293.87	1970.11	−14.11
	33	3732.53	2752.49	−26.26

Results and Discussion

CHANGES IN ANNUAL PRECIPITATION

The analyses using the cumulative deviations and Mann-Whiney-Pettitt statistic tests yielded the change points of all stations presented in Table III; for each station, both tests identified the same change point. This table demonstrates that the change points in North Taiwan are different, but most are in around 1960. In central and southern Taiwan, the change points are more consistent with each other and in approximately 1960. The above results are consistent with the research of the IPCC (2001), which found that the ocean temperature changed markedly in 1960, and that this change may affect the precipitation trends.

The annual precipitation series of each station was divided into two periods by the change point, as indicated in the third column of Table IV. The Kruskal-Wallis test was performed to determine whether the two sample groups had the same population. In this test, the null hypothesis H_0 is that the populations of the two sample groups are the same. The 95% confidence level was adopted. If $H > \chi^2_{(0.95,1)} = 3.84$, then the populations of the two sample groups differ substantially and H_0 is rejected. The results are presented in the fourth column of Table IV, which reveals that the annual precipitation series for most stations differ markedly between the two periods separated by the change point. The mean values of annual precipitation before and after the change point were calculated for each station as shown in Table V, to compare further the difference between the annual precipitations in the two periods. The table demonstrates that the stations (except Station No. 4) in northern and eastern Taiwan show increasing annual precipitation and most stations (except Station No. 12, 13 and 14) in central and southern Taiwan show falling annual precipitation.



Northern Taiwan Northern Taiwan

Figure 3. Box plots displaying change values of mean and standard deviation of monthly precipitation between the two periods. (Circle point: deviance value, Triangle point: extreme value)

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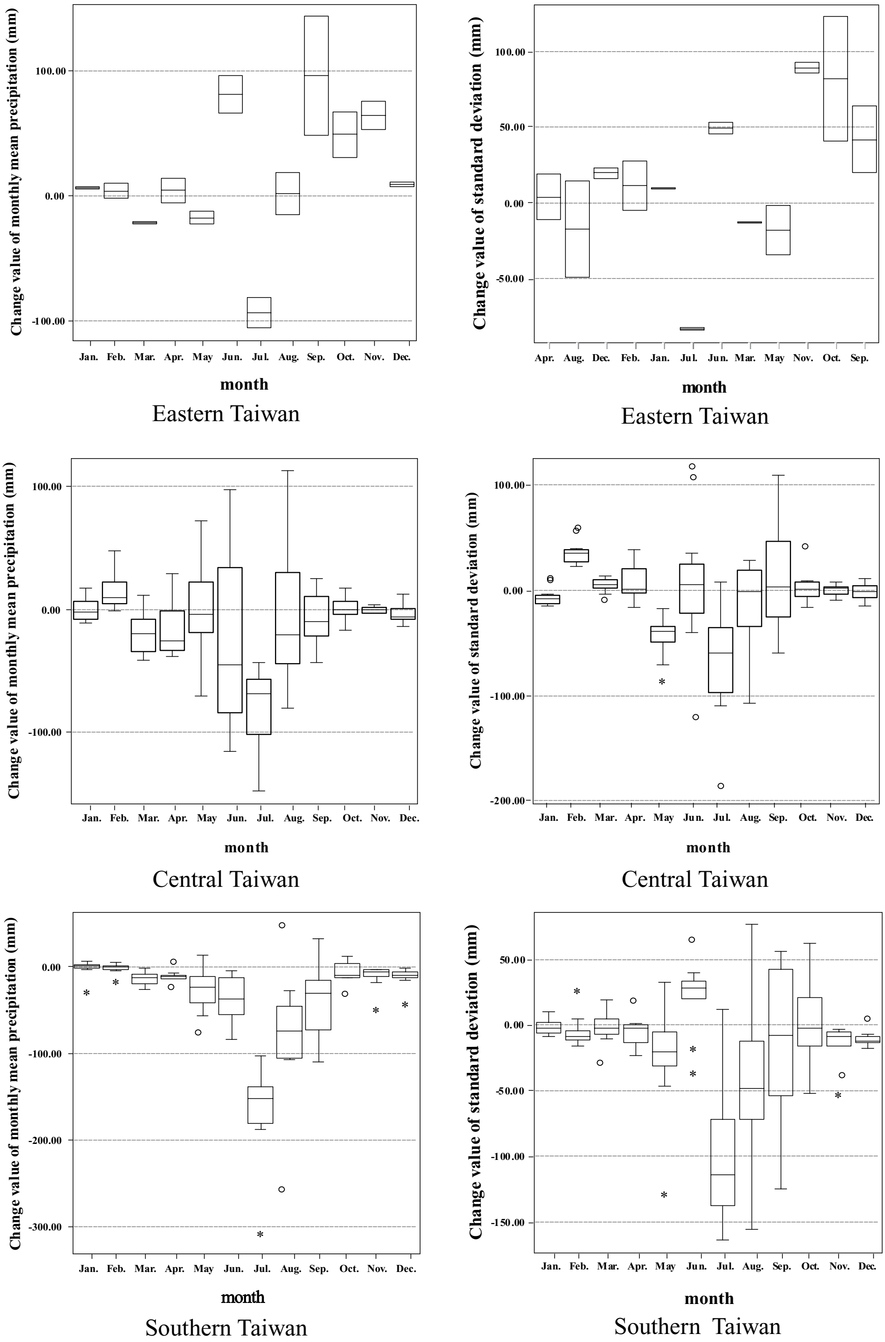

Figure 3. (Continued)

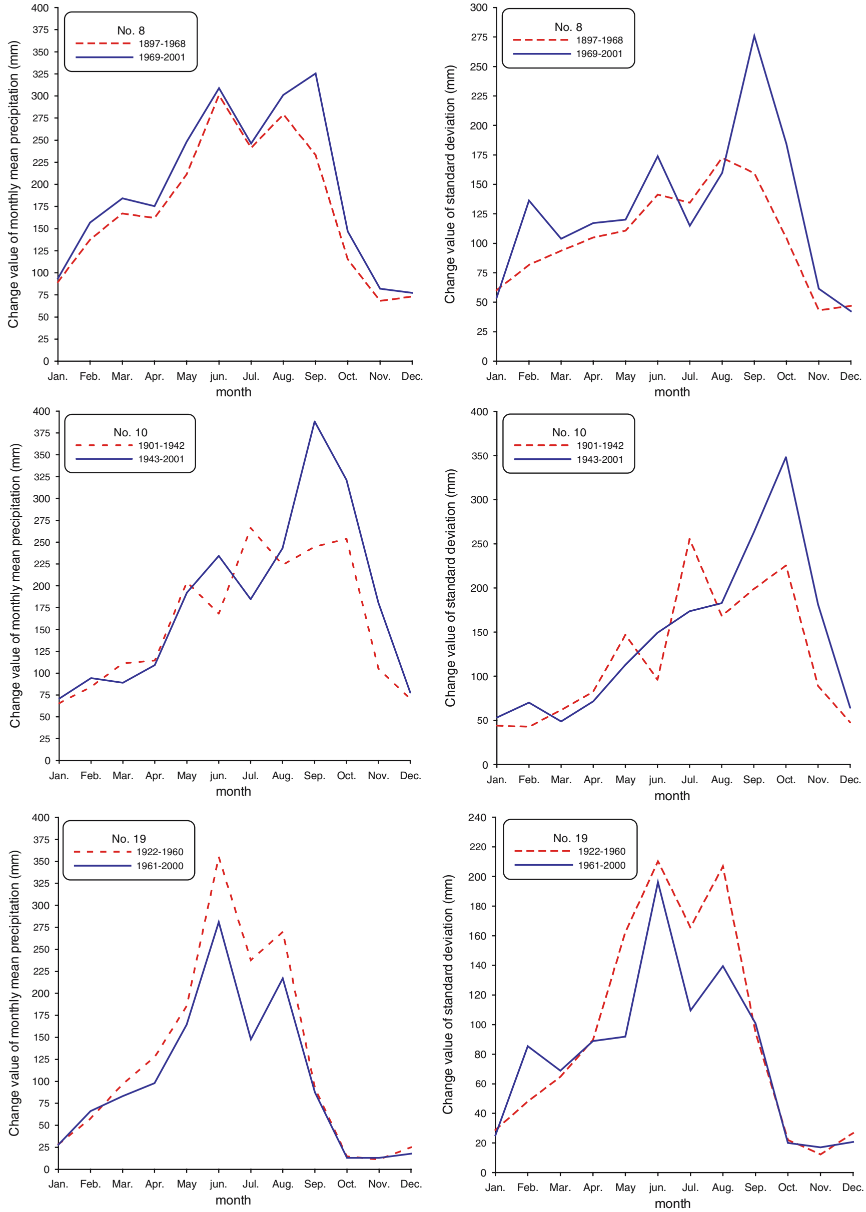

Figure 4. Change values of mean and standard deviation of monthly precipitation between the two periods for each month at Stations Nos. 8, 13 19, and 33.

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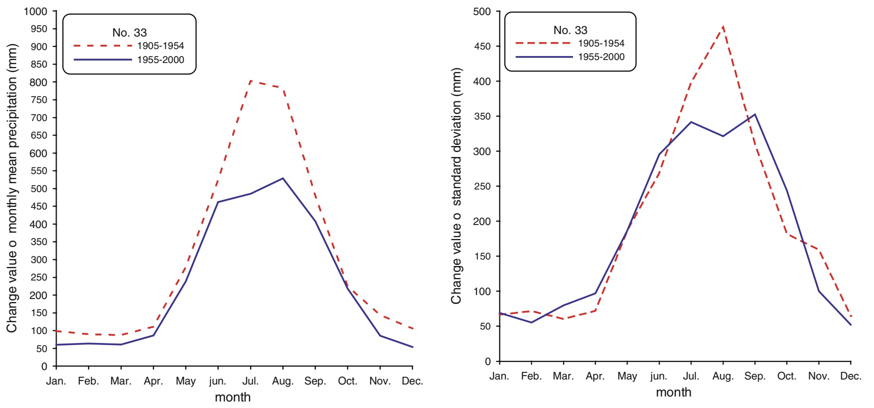

Figure 4. (Continued)

CHANGE IN MONTHLY PRECIPITATION

Based on the results of the analysis of the annual precipitation trend, the difference between the monthly precipitations in the two periods separated by the change point, were examined at every station. At each station, the means and standard deviations of the monthly precipitations were estimated for both periods. The change in the mean and standard deviation between the two periods were further determined at each station. Figure 3 displays box plots, which present the change values at the stations in the various regions in every month. This figure shows that most of the changes in the means and standard deviations of the monthly precipitations are positive, indicating that the monthly precipitations the monthly precipitations have increasing trends and the variation of monthly precipitation becomes larger during most of months in North Taiwan. Most of the changes in the means and standard deviations of the monthly precipitations in central and southern Taiwan are negative, revealing that the monthly precipitations drop and the monthly precipitation has fallen more stably in recent years. However, the changes in the mean and standard deviation of monthly precipitation in eastern Taiwan are inconsistent each other only two stations may not represent this area. The changes in means and standard deviations of monthly rainfall at four stations (Nos. 8, 10, 19, and 33), which were chosen from each region are shown in Figure 4.

CHANGES IN SEASONAL PRECIPITATION

In Taiwan, three major seasons are defined by their rainfall characteristics. One is the Mei-rain season during May and Jun; another is the typhoon season from July to September, and the other is the dry Season from November to April of the following year. The seasonal rainfall in the two periods separated by the change point is discussed below.

Table VI. Change percentage (%) of seasonal precipitation between the two periods for each station

Region	Station no.	Mei-rain Season	Typhoon season	Dry season
North	1	−0.24	10.53	12.96
	2	8.27	21.01	22.34
	3	20.00	1.72	9.56
	4	−4.99	−8.83	−9.67
	5	4.76	**21.12**	5.56
	6	2.41	14.77	−0.89
	7	−3.88	**32.79**	4.76
	8	8.73	15.79	10.27
	9	11.24	12.26	10.29
East	10	**14.42**	11.03	12.83
	11	20.44	−7.69	20.25
Central	12	19.04	−0.70	15.65
	13	**26.46**	−2.20	20.08
	14	21.21	−4.20	15.85
	15	−6.22	−16.88	**−18.18**
	16	**−22.16**	−11.33	**−14.83**
	17	−14.94	−13.63	**−15.43**
	18	−8.76	−11.36	−2.90
	19	−17.60	**−24.62**	**−11.85**
	20	−15.89	**−23.20**	**−17.06**
	21	−7.19	−6.24	**−20.58**
	22	−3.36	−6.44	**−11.71**
	23	−16.51	−11.82	**−16.85**
South	24	−8.66	−4.79	−14.76
	25	−12.63	**−25.91**	−14.74
	26	−6.06	**−28.14**	−14.16
	27	−11.18	**−20.34**	−9.91
	28	**−17.51**	**−22.18**	**−24.64**
	29	−9.22	**−16.79**	−12.29
	30	−5.32	**−21.42**	−27.28
	31	−7.93	**−16.96**	−11.70
	32	−3.99	**−19.57**	−15.37
	33	−12.82	**−31.17**	**−35.56**

Note. The number in **bold** indicates a statistically significant change by Kruskal-Wallis test ($\alpha = 0.05$).

The total precipitations in the Mei-rain Season were determined for each year in each station. The values were separated into two sample groups by the change point. At each station, the averages were calculated individually for the two sample groups and the percentage change in the average was determined as shown in the third column of Table VI. The Kruskal-Wallis test was used to test whether the two sample groups differ statistically significantly. In Table VI, numbers in bold indicate significant changes. The table demonstrates that the mean precipitation at most stations in the Mei-rain season increases in Northern and Eastern Taiwan, and declines in Central and Southern Taiwan. However, these changes are not statistically significant.

Following the above process, the percentage change in the average in the typhoon season and the dry season were determined as shown, respectively, in the fourth and the fifth columns of Table VI. The mean precipitations in the typhoon season at most stations increase in northern Taiwan and decrease in central and southern Taiwan. The falls at most stations in Southern Taiwan are statistically significant. The mean precipitations in the dry season at most stations in northern and eastern Taiwan increase and in central and southern Taiwan decrease. The declines at most stations in central Taiwan are statistically significant.

Conclusions

Many studies have analyzed trends in precipitation, since climate change has become a major global issue. Such studies have been published in various regions of the world and improved our understanding of global climate change. This work presents long-term precipitation trends in Taiwan and contributes these results concerning local climate change to improve our understanding of global climate change. Long historical rainfall records obtained from 33 raingauges yielded an analytical data set that elucidated variations and tendencies on various time scales (annual, seasonal and monthly rainfalls). The statistical tests, the cumulative deviation test and the Mann-Whitney-Pettitt statistic test, were used to find the change point in annual precipitation series at each station. Almost all of these change points were in the 1960s. The Kruskal-Wallis test was then conducted to determine whether the two sample groups separated by the change point differed significantly on various time scales (annual and seasonal rainfalls).

This study concludes that rainfall in northern and eastern Taiwan increased on various time scales, but in central and southern Taiwan decreased. However, only during the dry season in central Taiwan and the typhoon season in southern Taiwan was the variation significant.

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