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# Trends in precipitation in Thailand from 1964 to 2012

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## Abstract

In the present study, trends in 6 annual precipitation indices (CDD, CWD, R10, R20, RX1, and SDII) to observe long term trends in precipitation have been investigated for 48 stations over Thailand from 1964 to 2012. Trends were estimated using Mann-Kendall Test and Theil-Sen’s estimator. In general, the number of dry days is increasing, while the number of wet days is decreasing. The number of days with precipitation amounts above 10 and 20 mm showed opposite trends with no spatial coherence, which could be attributed to the relatively low station density. However, the slight majority of these trends is increasing. The maximum 1-day precipitation amount index showed a non-significant, spatial coherent increase in the central-west of North Thailand. Applying the simple daily intensity index, the majority of trends is increasing, whereas no spatial coherence was found. According to the spatial mapping, Central Thailand and its vicinity can be considered as the most threatened area of Thailand regarding extreme precipitation events.

**Keywords**: Precipitation trend, Indices, Thailand, Mann-Kendall, Theil-Sen’s estimator

## 1. Introduction

Changes in the daily precipitation and increasing trends in extreme precipitation events have been observed in several areas of the world [1]. Furthermore, the variance of precipitation is increasing and wet areas become wetter and dry areas become drier [2].

It is proven that the increasing amount of anthropogenic greenhouse gases in the atmosphere contribute to more heavy precipitation events over the Northern Hemisphere [3]. The link between temperature and precipitation suggests that the future changes in precipitation extremes may be underestimated, as climate models seem to underestimate the response of precipitation extremes to increased temperatures [3]. The global reallocation of precipitation is driven by climate change and adverse consequences, e.g. the regional availability of food supply, will probably affect the least developed countries [2].

This study aims to investigate trends in precipitation for 48 meteorological stations, featuring long term data (49 years), distributed over Thailand. Spatial mapping of the trends is applied to enable the evaluation of threatened areas of precipitation changes. Precipitation trends are of great interest as the country experiences regular flooding events [4].

## 2. Materials and methods

### *2.1. Data*

Daily records of precipitation data for 48 meteorological stations from 1964 to 2012 were provided by the Thai Meteorological Department (TMD). The locations of the stations are shown in Figure 1 and were separated in North, North-Easter, East, Central and South Thailand. The total missing data of all stations is 0.79 %. Therefore, the data was not completed and missing values were replaces by NA (Not Available). In the present study, 6 indices on an annual basis, abbreviations and calculation can be found in Table 1, were calculated from the records for each station.

### *2.2. Trend Estimation*

The non-parametric Mann-Kendall test was applied to detect significant monotonic trends in the time series [5] & [6]. The null hypothesis (H0) is that the time series values are independent, normal distributed and no trend exists. The Mann-Kendall test statistics (S) for a time series of the length n is given by equation:

$$S = \sum_{k=1}^{n-1} \sum_{j=k-1}^{n} \operatorname{sgn}(x_j - x_k) \tag{1}$$

Where x (j )and x_k are precipitation indices at time j and k, whereas j > k and sgn:

$$\operatorname{sgn}(x_j - x_k) = \begin{cases} 1 \text{ , if } x_j - x_k > 0 \\ 0 \text{ , if } x_j - x_k = 0 \\ -1 \text{ , if } x_j - x_k < 0 \end{cases} \tag{2}$$

According to H0, no trend exists if the time series is independent and normal distributed with:

$$E(S) = 0 \tag{3}$$

$$V(S) = \frac{[n(n-1)(2n+5)]}{18} \tag{4}$$

Where E(S) is the expected value for S and V(S) the variance of S. The standardized Mann-Kendall test statistics Z is calculated using the following equation:

$$Z = \begin{cases} \frac{S-1}{\sqrt{V(S)}} \text{ , if } S > 0 \\ 0 \text{ , if } S = 0 \\ \frac{S+1}{\sqrt{V(S)}} \text{ , if } S < 0 \end{cases} \tag{5}$$

H0 is rejected if $|Z|$ is greater than $Z_{a/2}$, where a represents the significance level. In the present study the 10 % significance level was chosen. Thus, a trend is considered statistically significant if $|Z| > Z_{0.05}$.
The slope (b) of the significant trends was estimated using non-parametric Theil-Sen's estimator [7] & [8] given by equation:

$$b = \text{median}\left[\frac{X_i - X_j}{i-j}\right], \text{for all } \forall\, j < I \tag{6}$$

Where $X_i$ and $X_j$ are precipitation indices at time i and j, whereas i > j. Compared to the least-square method, the slope (b) is estimated on the basis of the median of the records, which makes it less affected by outliers.

## **3. Results**

Trends in CDD and CWD showed opposite trends, as expected (Figure 1). The CDD showed an increase in 74 % of all present trends, whereas the CWD showed a decrease in 76 % of all present trends. It is remarkable that stations located in Central Thailand and its vicinity, exhibit a spatial coherent significant increase in CDD and decrease in CWD. The significant trends in this area have a magnitude of 3 and 6 days per decade and -3 and -6 days per decade for CDD and CWD, respectively.

The spatial mapping of trends in R10 and R20 precipitation indices is shown in Figure 1. R10 and R20 indices investigate heavy precipitation and show a similar pattern, as for both indices, the number of non-significant increases equals the number of non-significant decreases. In case of significant trends, the number of increases slightly exceeds the number of decreases. No spatial coherent trends could be found. However, it becomes apparent that Central and East Thailand have the most pronounced trends ranging from -4 to 4 days per decade and -2 to 4 days per decade for R10 and R20, respectively.

RX1 shows the highest number of non-significant trends (n=44). Despite the high number of trends, no spatial coherence can be seen, except for the central-west of North Thailand (Figure 1). Applying SDII, trends for all 48 stations have been detected. The majority of the trends is increasing (n=28), whereas the number of non-significant increases (n=18) equals the number of non-significant decreases (n=18). Significant trends ranging from -0.5 to 2 mm per day per decade were observed. A spatial coherence of trends has not been found (Figure 1). The same analysis was performed using only data in the rainy season, May to October, revealing only slight differences compared to the annual analysis (not shown).

## 4. Discussion

In a study from Sharma and Babel [9] trends in 11 extreme precipitation indices for 15 meteorological stations in western Thailand from 1961 to 2002 were investigated. It was found that for most of the 15 analyzed stations, trends in CDD are increasing. Additionally, opposite trends to CDD were observed in CWD. Similar results for CDD and CWD were found by investigating trends in extreme precipitation over Southeast Asia, including Thailand [10]. Most of the analyzed stations match with the stations in the present study. However, opposite trends in CDD were investigated for 6 stations. Based on these results and in agreement with the literature, it can be concluded that for the vast majority of stations, the number of wet days is decreasing, whereas the number of dry days is increasing.

The study from Sharma and Babel [9] found decreasing trends in R10 and R20 for all but one station. Furthermore, no spatial coherence of R10 and R20 is observed in the present study. This could be partially explained by a lower station density, whereby smaller spatial coherencies cannot be investigated.

A non-significant, spatial coherent increase in RX1 is observed in the central-west of North Thailand, which partially covers the study area of [9], whose results show a non-significant increase in RX1 for the majority of analyzed stations. In the present study, the narrow majority of SDII trends is increasing, which is agrees with the literature [10].

## 5. Conclusions

In summary, CDD is increasing, while CWD is decreasing in Thailand. The heavy precipitation indices R10 and R20 show opposite trends with the slight majority of trends increasing. Furthermore, R10 and R20 show a similar behavior, but no spatial coherence, which could be attributed to the relatively low station density. RX1 showed a non-significant, but spatial coherent increase in the central-west of North Thailand. For SDII, the majority of trends is increasing, whereas no spatial coherence was found. Central Thailand and its vicinity experience the most dramatic progression regarding the magnitude of the trends. Thus, Central Thailand and its vicinity can be considered as the most threatened area of Thailand regarding extreme precipitation events.

**Table 1** Precipitation indices used in the present study

| Index | Name | Definition | Unit |
|---|---|---|---|
| CDD | Consecutive dry days | Max. no. of consecutive days with P*<1 mm | Day |
| CWD | Consecutive wet days | Max. no. of consecutive days with P*≥1 mm | Day |
| R10 | Number of days above 10 mm | Annual count of days with P*≥10 mm | Day |
| R20 | Number of days above 20 mm | Annual count of days with P*≥20 mm | Day |
| RX1 | Max 1-day precipitation amount | Annual max. 1-day precipitation | mm |
| SDII | Simple daily intensity index | Annual total precipitation divided by the annual no. of wet days (P*≥1 mm ) | mm day$^{-1}$ |

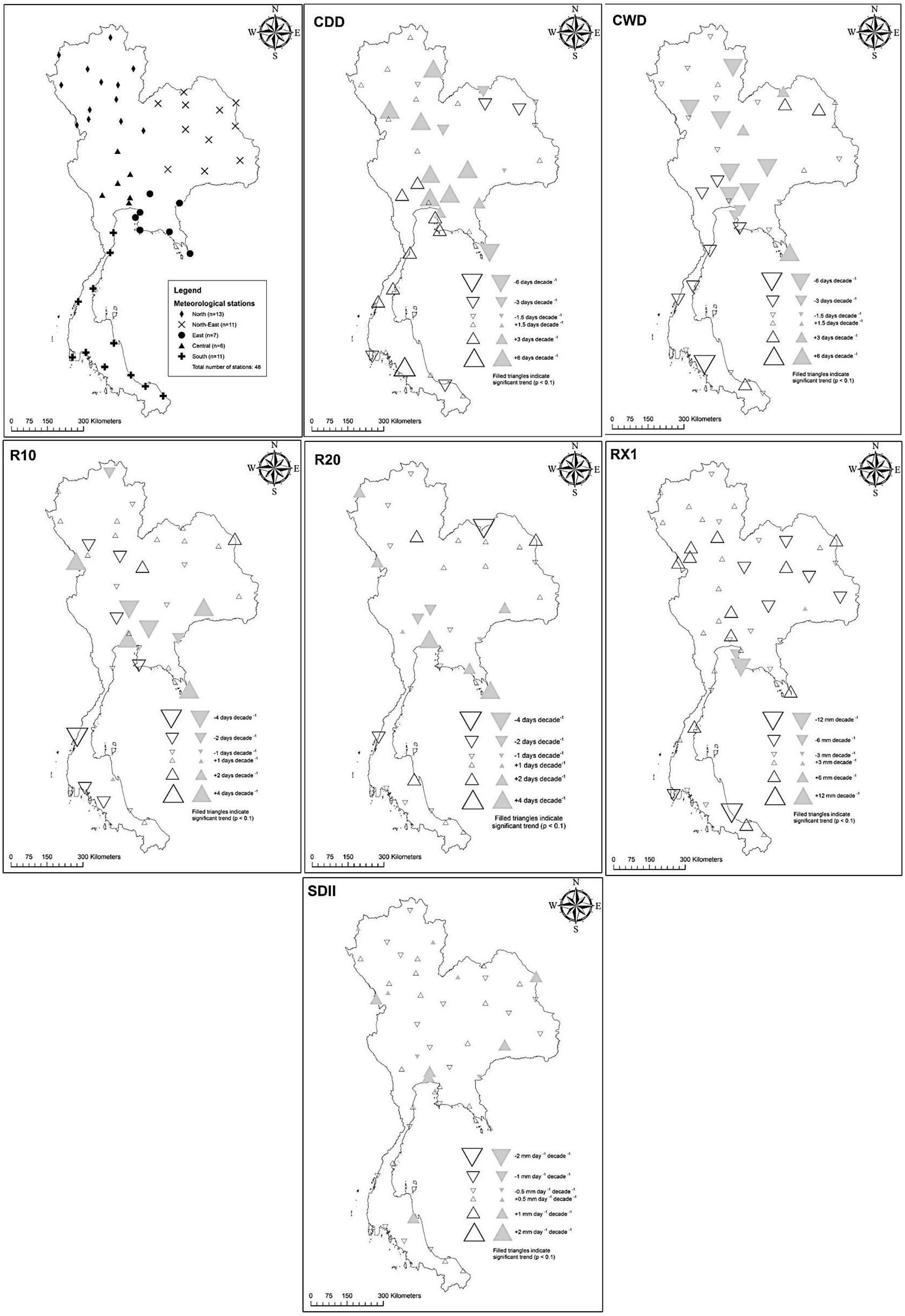

**Figure 1** Locations of the meteorological stations and trends in precipitation indices

## 6. References

[1] Karl, T.R., Knight, R.W., 1998. Secular trends of precipitation amount, frequency, and intensity in the United States. Bulletin of the American Meteorological society 79, 231-241.

[2] Dore, M.H., 2005. Climate change and changes in global precipitation patterns: what do we know?. Environment international 31, 1167-1181.

[3] Min, S.K., Zhang, X., Zwiers, F.W., Hegerl, G.C., 2001. Human contribution to more-intense precipitation extremes. Nature 470, 378-381.

[4] Gale, E.L., Saunders, M.A., 2013. The 2011 Thailand flood: climate causes and return periods. Weather 68, 233-237.

[5] Mann, H.B., 1945. Nonparametric Tests Against Trend. Econometrica 13, 245-259.

[6] Kendall, M.G., 1948. Rank correlation methods. Oxford, England: Griffin.

[7] Raj, B., Koerts, J., 1992. Henri Theil’s Contributions to Economics and Econometrics. Springer Netherlands, 345–381.

[8] Sen, P.K., 1968. Estimates of the Regression Coefficient Based on Kendall’s Tau. Journal of the American Statistical Association 63, 1379-1389.

[9] Sharma, D., Babel, M.S., 2014. Trends in extreme rainfall and temperature indices in the western Thailand. International Journal of Climatology 34, 2393-2407.

[10] Endo, N., Matsumoto, J., Lwin, T., 2009. Trends in precipitation extremes over Southeast Asia. Sola 5, 168-171.