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Trends in temperature in Thailand from 1964 to 2013

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Abstract

Surface air temperature is one of the most important climate factors. Globally, minimum temperatures are increasing at a faster rate than maximum ones. In this study, Thailand's trends in daily maximum surface air temperature (Tmax), minimum surface air temperature (Tmin), and the diurnal temperature range (DTR) from 1964 to 2013 were observed and interpolated. The results were compared with other studies and demonstrate that the trends in Tmax and Tmin are increasing, whereas the DTR is most often decreasing due to the increase of Tmin at a faster rate than that of Tmax. As surface air temperature changes can be seen as indicators of climate change, the findings indicate that Easter, Central and West Thailand appear to be the most impacted areas of Thailand over the past 50 years (1964-2013) regarding rapid surface air temperature changes. To further understand the changes in Thailand's climate, trends in precipitation intensities should be evaluated.

Keywords: Climate change, Thailand, Temperature series, EM method, Mann-Kendall test

1. Introduction

Increasing surface air temperatures have been observed all over the globe since 1950 [1]. Several studies reported an asymmetric trend in daily maximum and minimum temperature over the last decades [1], [2] & [3]. It has been observed that the global minimum temperature increases at a faster rate than the maximum temperature, which leads to a decrease in the diurnal temperature range [1].

Shifting environmental conditions as a result of climate change can have socioeconomic impacts such as food insecurity, flooding, and land degradation [4]. As Thailand is a predominantly agricultural country, climate change and its consequences are of central importance for its economy and society.

The aim of this study is the investigation of trends in surface air temperatures in Thailand and the spatial analysis of these trends by applying interpolation technique. In the context of climate change, spatial analysis is important for assessing the risk of impacts of climate change and developing adaptation plans.

2. Materials and methods

2.1. Study area and data

The dataset for this study was provided by the Thai Meteorological Department (TMD) and is comprised of daily records of maximum surface air temperature (Tmax) and minimum surface air temperature (Tmin) from 1964 to 2013. 50 meteorological stations (Figure 1), featuring long term data (50 years), were chosen to be analyzed. In order to ensure the quality of the data, real-time and non-real-time control is performed frequently by the TMD [5].

For the analysis, monthly means of Tmax and Tmin were computed based on daily records. If daily records were missing, the monthly data was also considered as missing. The resulting missing data of monthly Tmax and

Tmin was 0.86 % and 0.78 %, respectively. In addition, the diurnal temperature range (DTR) was calculated as DTR = Tmax - Tmin.

2.2. Missing Data Imputation and Homogeneity Check

As each station's trend represent an area, it becomes important that the determination of the trends is based on high quality data. In order to achieve this high quality, all monthly temperature series were completed and checked for their homogeneity.

The Expectation Maximization (EM) algorithm [6] was applied to fill in missing values in the temperature series. The EM algorithm is an iterative method computes maximum likelihood estimates from incomplete data. The EM method has been recommended by several studies [7 & 8].

To ensure the data's homogeneity, Penalized Maximal t Test (PMT) in the RHtestV3, an R-based software package developed by the Climate Research Division of Meteorological Service of Canada, was applied [9].

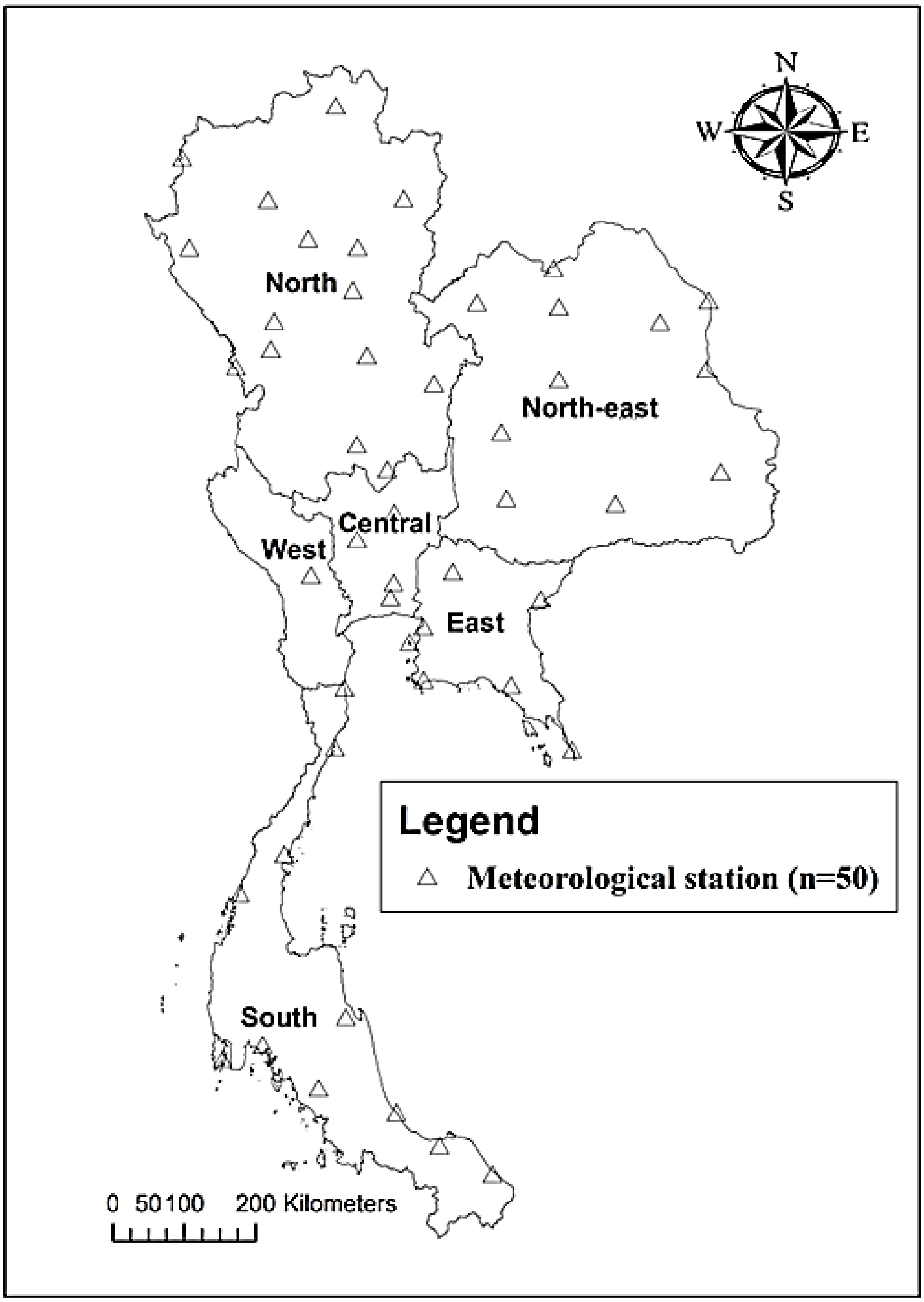

Figure 1 Study area, regions of Thailand and the locations of the 50 meteorological stations

2.3. Trend Determination

The determination of trends in the temperature series of each station is based on the annual anomalies of each data series. Therefore, the anomalies are defined as the difference between the annual value of each year and the annual mean of the reference period from 1964 to 2013 for each station. In order to determine the trends, linear regressions were calculated applying non-parametric Theil-Sen (TS) estimator [10] & [11]. TS estimates slopes of a linear regression by using the median slope, which makes it less affected by outliers than using parametric least-square method.

The statistical significance of the trends was assessed by using non-parametric Mann-Kendall (MK) test for a monotonic trend. MK is a widely applied method for testing for a monotonic upward or downward trend in time series [12] & [13]. Trends at the 5 % level were considered to be statically significant.

2.4. Interpolation Technique

In this study, Inverse Distance Weighting (IDW) method was chosen for the spatial interpolation of the temperature trends in ArcMap 10.1. IDW creates a raster surface in which each value of a raster cell is calculated by weighting the sum of values at nearby sample points. Thus, the weight of each sample point is a function of the inverse of the distance between the sample points and interpolated raster cell.

3. Results

In the trend determination, only positive trends have been found for Tmax and Tmin. For DTR, a few increasing trends (26 %) were found, but the majority of the trends (74 %) were decreasing. The interpolated Tmax trends show a relatively high warming in Easter and Central Thailand (Figure 2 a)). North and South Thailand feature a wide range of trends. Across these regions, the warming is within a range of 0.10 to 0.40 °C/dec. Figure 2 b) shows the interpolation of the Tmin trends. The most rapid warming in Tmin has been observed in Easter, Central and West Thailand. In contrast, the rest of Thailand tends to warm within a relatively wide range of 0.05 to 0.45 °C/dec.

Figure 2 c) shows increasing and decreasing trends in almost every region, except for Central and West Thailand. Central and West Thailand show a consistent decrease in the DTR. Especially for the trends in the DTR, increasing and decreasing trends can be observed in North, West and South Thailand ranging from -0.40 to 0.35 °C/dec. The averaged trends indicate that Tmin is increasing at a faster rate than Tmax (Table 1). As a result, the average DTR trend is decreasing by -0.09 ± 0.18 °C/dec.

Trends in Tmin, Tmax, and DTR in Thailand were also analyzed by Limjirakan and Limsakul [14]. Comparing the averaged trends to the trends of Limjirakan and Limsakul [14], it can be found that the trends differ only 0.02 and 0.01 °C/dec for Tmax and Tmin, respectively. In case of the DTR trend, the average trend differs only 0.004 °C/dec [3].

4. Discussion

In this study, a pattern that Tmin increases at a faster rate than Tmax has been detected. The faster increase of Tmin is results in a decrease of the DTR, which has also been observed by several studies all over the globe [1], [3] & [14]. Karl et al. [1] attribute the deceasing DTR to, inter alia, changes in cloud cover, precipitation, and land use. To further understand the changes of Thailand’s climate, trends in precipitation intensities should be evaluated.

5. Conclusions

In conclusion, Thailand’s surface air temperatures show a warming over the past 50 years with spatial differences. As surface air temperature changes can be seen as indicators of climate change, the findings indicate that Easter, Central and West Thailand appear to be the most impacted areas of Thailand over the past 50 years (1964-2013) regarding rapid surface air temperature changes.

Table 1 Average trend [°C/decade] and its standard deviation in Tmax, Tmin and the DTR

Temperature variable	Tmax	Tmin	DTR
Average trend [°C/dec] ± standard deviation	0.22 ± 0.09	0.27 ± 0.12	-0.09 ± 0.18
Percentage of stations at the 5 % level [%]	90	98	76

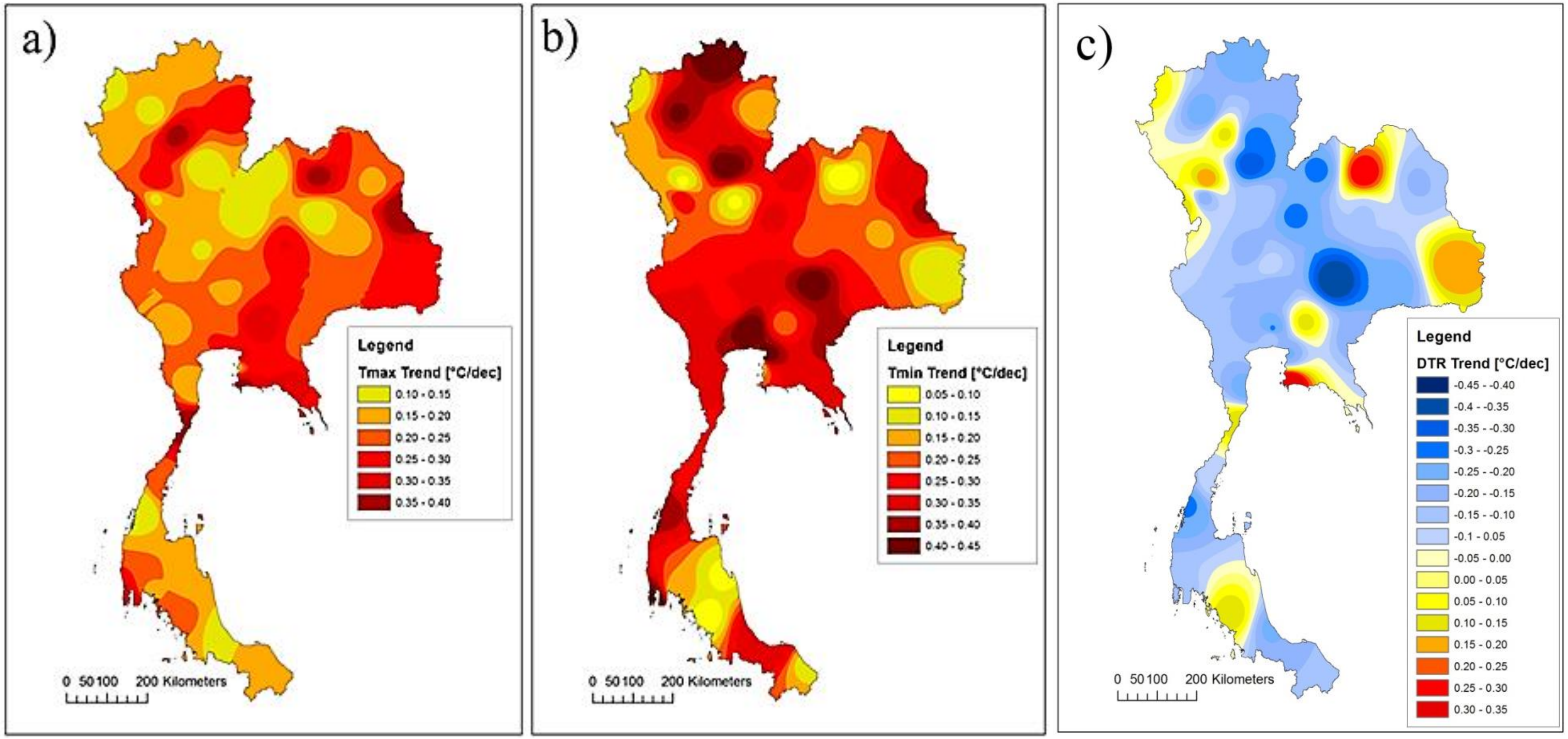

Figure 2 Interpolated trends in Tmax (a)), Tmin (b)), and DTR (c)) from 1964 – 2013

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