Use of 95th Percentile Temperature Data to Identifying the Heatwaves: A Novel Case Study in Anuradhapura, Sri Lanka

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Abstract – Heatwave is a prominent natural disaster observed in recent decades due to the presence of extremely hot weather. Even though the heatwave could be defined based on the hydrometeorological aspects, the studies on heatwave impact are mostly concerned with the health of human beings. Despite that, this study attempts to identify the heatwaves for April and May in the Anuradhapura district in Sri Lanka. The study used a novel approach – the 95th percentile of temperature to identify the heatwaves. Seven hot days were identified during April and May for the Anuradhapura region for the study period. Nevertheless, there is only one cold night was observed in the region during the last week of May. Based on the selected novel approach, it is identified the absence of heatwaves in the region during April and May. Even though April and May are identified as the hottest months for the region, the months receive a comparable amount of rainfall to suppress the generated heat during day time. Further, it is suggested to apply the same methodology to a season or year to identify the occurrence of seasonal and annual heatwaves in the region. Furthermore, the assessment of teleconnection between rainfall and atmospheric-oceanic oscillation with heatwaves is suggested.

Keywords: Heatwave, Anuradhapura, 95th percentile temperature

I. INTRODUCTION

The heatwave could be defined as a natural disaster due to climate change-induced extremes such as extremely hot weather with excessive temperature and humidity, and low rainfall [1]. In addition, latent cooling due to high temperature-influenced soil moisture depletion, recurrent high-amplitude Rossby wave for the hemisphere, atmospheric-oceanic oscillations like El-Nino Southern Oscillation (ENSO) and North Atlantic Oscillation, and anthropogenic activities such as urban heating and emission of greenhouse gas amplify the impacts of heatwaves.

The diverse definitions for heatwaves were derived regionally/locally mainly based on the temperature threshold levels observed in the regions/countries which could affect their citizens. Therefore, The World Meteorological Organization (WMO) generalized the globally accepted definition for heatwaves such as the presence of warming air, in which the daily maximum temperature (TMax) is higher than the mean temperature (i.e., between 1961 and 1990) by 5°C or more for 5 or more consecutive days and destroy routine human activities [2]. Nevertheless, WMO differentiated heatwave from warm spells, such as warm spells defined based on 90th or 95th percentiles of daily TMax and can be observed at any time of the year, whereas heatwaves can only be observed during the warm season. Many scientists focused on analyzing heatwave impact on the health of living beings – humans, but heatwave-associated droughts including flash droughts directly impact agriculture.

Ampitiyawatta et al. [3] showed that the 90th percentile of maximum and minimum temperatures between 1975 and 2005 in Anuradhapura were 35.4 ◦C and 25.5 ◦C, respectively. Furthermore, identified a significant increasing trend in warm nights in both the Maha and Yala seasons, where the higher increase was observed in Maha season. Despite that, this study attempts to identify the occurrence of heatwaves in the Anuradhapura district in Sri Lanka for April and May as a preliminary study using a novel approach of the application of daily mean 95th percentile temperature data.

II. DATA AND METHODS

A. Data

Two main data types – daily maximum temperature (TMax) and daily minimum temperature (TMin) data for Anuradhapura were used for the study. The available daily data consist from 1961 to 2015 (i.e., 55 years).

B. Methodology

The methodology developed by Kuglitsch et al. [4] was used to identify heatwave duration for the study with minor modifications. The daily time series of TMax and TMin for the April and May months (61 days) for each year were developed.

The long-term daily 95th percentiles were calculated using the daily TMax and TMin from March to June (i.e., one month lap from both ends), which is the calculation procedure developed by Della-Marta et al. [5]. Firstly, the mean daily TMax and TMin series for the months from March to June were calculated. In this method, the mean temperature of a certain day was calculated by averaging the temperature of a given day for entire selected years i.e., 55 years. Secondly, the 95th percentile of a certain day was calculated based on the sample of 15 days. The 15 days included seven days before and after the selected day. The 95th percentiles for each day between March to June were calculated for both the TMax and TMin daily time series. Finally, the heatwave is identified where both the mean daily TMax and TMin exceed their respective 95th percentiles by plotting the mean daily climatologies of TMax, TMin, and mean daily 95th percentiles of TMax and TMin.

Originally Della-Marta et al. [5] identified heatwave duration based on the period of three or more consecutive hot days and nights not interrupted by more than a non-hot day or night. Nevertheless, noted that in this study, the consecutive days of temperature which exceed both the mean daily 95th percentiles of TMax and TMin are identified as a heatwave duration.

Matlab R2019b software was used to analyze the data in this study.

III. Results And Discussion

A. The observed highest and lowest temperatures

The highest mean daily TMax of 35.4°C was observed on the 1st of April and the mean daily TMax gradually declined during April and May (Figure 1). The lowest mean daily TMax was 32.2°C for the Anuradhapura district. Nevertheless, the region receives monthly rainfall of 158.3 mm and 78.8 mm for April and May, respectively and due to this reason, TMax tends to decrease gradually from April to May.

On the other hand, the highest mean daily TMin or highest daily night temperature observed for the region was 25.4°C on the 58th day of the season selected or the 28th of May. The lowest mean daily TMin observed for the selected months was 24°C. Nevertheless, the mean daily TMin for the selected months gradually increased (Figure 1). The generated heat during the daytime could suppress due to the persisting rainfall during April.

B. 95th percentiles observed for the duration

The mean daily 95th percentiles for TMax vary between 32.9°C and 35.3°C. There are 7 hot days (i.e., mean daily 95th percentile for TMax exceeds the mean daily TMax) identified in this study, and Table 1 shows the identified hot days and respective temperature values (i.e., mean daily TMax and mean daily 95th percentile for TMax).

It is interesting to identify that there were no cold nights (i.e., the mean daily TMin did not exceed its relevant daily 95th percentiles for April and May for the region), except on 28th May. Nevertheless, the mean daily 95th percentile for TMin varies between 24.4°C and 25.4°C.

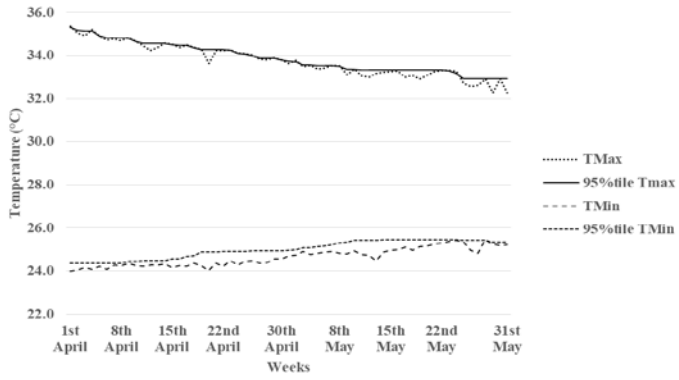

Fig. 1 The distribution of mean daily maximum and minimum temperatures, and 95th percentiles for the daily maximum and minimum temperatures April and May for the Anuradhapura district.

Table 1. Dates of hot days and their respective temperature values

Date	Mean daily TMax (°C)	Mean daily 95th Percentile TMax (°C)
1st April	35.4	35.3
4th April	35.2	32.1
10th April	34.7	34.6
23rd April	34.3	34.2
2nd May	33.8	33.7
4th May	33.6	33.5
24th May	33.3	33.2

Based on the results, it is identified that absence of heatwaves for April and May in the Anuradhapura district, where both the TMax and TMin did not exceed their corresponding 95th percentiles.

IV. Conclusion

This study adopted a novel approach of using 95th percentile temperature data to identify heatwaves in the Anuradhapura district. The study revealed the absence of heatwaves for April and May, even though there were a few hot days and one cold night for the selected season. Further, this study identified that there might be a relationship between rainfall and the changes over TMax and TMin.

Nevertheless, further investigation is suggested to continue the same methodology for a season or a year for the Anuradhapura district because analyzing for two months would not capture the effect of previous months' temperatures on the occurrence of heatwaves. It is suggested to assess the rainfall simultaneously with the temperature to identify the impact of rainfall on the dilution effect of heatwaves. Since Sri Lanka is an Island atmospheric-oceanic oscillations such as ENSO or Indian Ocean Dipole would impact the heatwaves in Sri Lanka. Therefore, it is suggested to assess the teleconnection between heatwaves and the related atmospheric-oceanic oscillations over Sri Lanka. Lastly, it is recommended to use robust data series for the calculation. The daily temperature series used in this study had a comparable amount of missing values and it would misguide the results and conclusion of the study.

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