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Monitoring Observed Changes in Warm-days Extremes over Turkey

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ABSTRACT

This study aimed to analyze warm-days changes extracted from daily maximum temperature time-series of 71 stations in Turkey during 1961–2016. First, the trend analysis of warm-days events indicated that the annual count of warm-days occurrences has been significance rising by a rate of 1.4 days per decade over more than 90 percent of the studied stations. Thus, there are consistent patterns in daily warming throughout the study area. The spatial maps showed that the lowest frequency in the minimum annual number of warm-days occurred in western areas by a total number of 21 days and its highest occurred in the eastern area by a total number of 35 days. Moreover, the highest frequency in the mean and minimum annual count of warm-days observed in the northwestern lowlands and their frequency has decreased toward the eastern mountainous. Also, the highest range of differences between the annual count of maximum and minimum values has happened in the eastern regions which are characterized by high elevation and the lower existence of atmospheric humidity. Therefore, a higher moisture content of the atmosphere in lowland coastal stations favors severe warm-days and the increased risk of human health.

***Keywords*:** Maximum Temperature; Extreme Event; Warm-days; Spatial-temporal Analysis; Turkey

1. Introduction

Nowadays, the Intergovernmental Panel on Climate Change (IPCC) paid a high attention to the observed changes in extreme indices (IPCC 2007). Changes in the average of climate time-series could cause a high variation in the weather extreme indices (Casanueva *et al*. 2014). Therefore, any changes in weather extremes will cause higher adverse impacts on any geographical region (Choi *et al*. 2009) and will lead higher losses in the social and economic societies (Zhang *et al*. 2017). A majority of studies have analyzed the spatial and temporal variation in these extreme events. In particular, the number of warm days' extremes has been globally reported to increase since 1950 (IPCC 2013). Also in the regional scale, the warming trends have been revealed for different parts of the world (e.g., Solomon *et al*. 2007; Kerr 2009; Simolo *et al*. 2014; Abbasnia and Toros 2018).

Nowadays, one sign of global warming is an increase in the occurrence of maximum temperatures events. In this way, analyzing the maximum temperature changes in the middle of the current century (2041-2070) will occur more severe. So that, in a study conducted by Abbasnia *et al*. (2016) showed an increase in the annual mean of maximum temperature about 0.1 °C to 3 °C in Iran area. Moreover, this study showed that the lowland regions of southern coast are expected to have the lowest increasing changes in the frequency of warm extremes compared to northern highlands. In the study area, also some studies are attempted to focus on periodic trends in the warm extreme events over the uneven topography of Turkey (e.g. Tayanc *et al*. 1997; Toros 2012; Unal *et al*. 2012; Öztopal 2017). Their results have been shown that there is a general tendency in the warm extreme temperature than the cold extreme temperatures. While no one of these previous studies focused to understand the details of long-term variation in warm-days extremes. The occurrences of warm-days events may result not only in the loss of life but also the loss of property resulting in a negative effect on the region. However, this study is aimed to detect temporal and spatial variation in warm-days extreme events on a scale of 71 synoptic stations throughout Turkey area during the period of 1961-2016.

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2. Data and Methodology

The study area covers the whole surface area of 783.562 square kilometers of Turkey country where lies geographically in the Northern hemisphere between latitudes 36° and 42° N, and longitudes 26° and 45° E. Due to uneven geographical diversity, the spatial distribution of temperature does not follow a consistent pattern. Distribution of Mean temperatures will generally increase from North to South and from East to West. In the present study, the daily maximum temperature time series on the point scales of 71 synoptic stations are taken from Turkish Meteorological Organization for the observation period of 1961 to 2016. First, reliability and accuracy of these data time series are tested for all stations and each outlier in time-series was manually checked using metadata per station scale. After the basic tests, the annual number of Warm Days index (WD) is extracted using the RClimDex software developed by the Canadian Meteorological Service (More details refers to Zhang and Yang 2004). In this case, warm-days are defined if the daily maximum temperature on the station scale is higher than the 90^{th} percentile threshold of an annual timescale. Next, the trends of the annual number of warm-days extreme were calculated based on a non-parametric Mann–Kendall test. Finally, the interpolation method of Kriging using the Arc/GIS is used to draw the spatial maps resulting from warm-days changes in Turkey area.

3. Results and Discussion

The results obtained indicated that the number of Warm Days (WD) has continued to increase over Turkey area from 1961 to 2016. Trend analysis of maximum temperature throughout study area showed that the daily temperature significantly is warmer as indicated by the indices of warm days. In this case, a broad significant increasing trend is evidenced by a rate of 1.4 days per decade at the significance level of 95% for the majority (90%) of the stations throughout the study area. Only a few numbers of the coastal studied station in the southeastern of black sea region have shown negative trends.

These results on the station scale of the coastal regions of the black sea could be linked to hydrological cycle characterized by the potential of atmospheric moisture. The previously reported results by Sensoy *et al*. (2013), also showed that the number of warm days has increased all over Turkey. It is also observed that since 1950 the number of warm days has increased on the global scale (IPCC 2013). After counting the number of warm days, the spatial distribution maps are drawn for the maximum, average, minimum and range annual mean frequency of Turkey's warm-days (**Figure 1**). As it is clear from the drawn spatial maps for the whole observation period (1961-2016), lowest frequency in the minimum annual count of warm-days has occurred in western areas by a total number of 21 days and its highest has occurred in the eastern area by a total number of 35 days during the whole studied period.

The mean and minimum annual count of warm-days has revealed same spatial patterns over the study area. In this regards, the highest frequency in the mean and minimum annual count of warm-days have happened in the high latitudes especially for northwestern region of Turkey. Then, these spatial patterns of both variables have decreased toward low latitudes especially for the southeastern mountains of Turkey area. Moreover, the highest range of differences between the annual count of maximum and minimum records for the warm days has obtained in the eastern regions which are characterized by high mountains. In contrast, the lowest range of annual count of warm-days has happened in the western and northern coasts which are characterized by high atmospheric humidity. Therefore, what is notable to mention here is that the spatial behavior of coastal stations compared to the highland stations showed differences due to their uneven topography and atmospheric humidity. Finally, the main characteristics of coastal stations such as their lowland locations and the existence of a high level of water vapor in their atmosphere cause the highest frequency of warm days to happen in these areas.

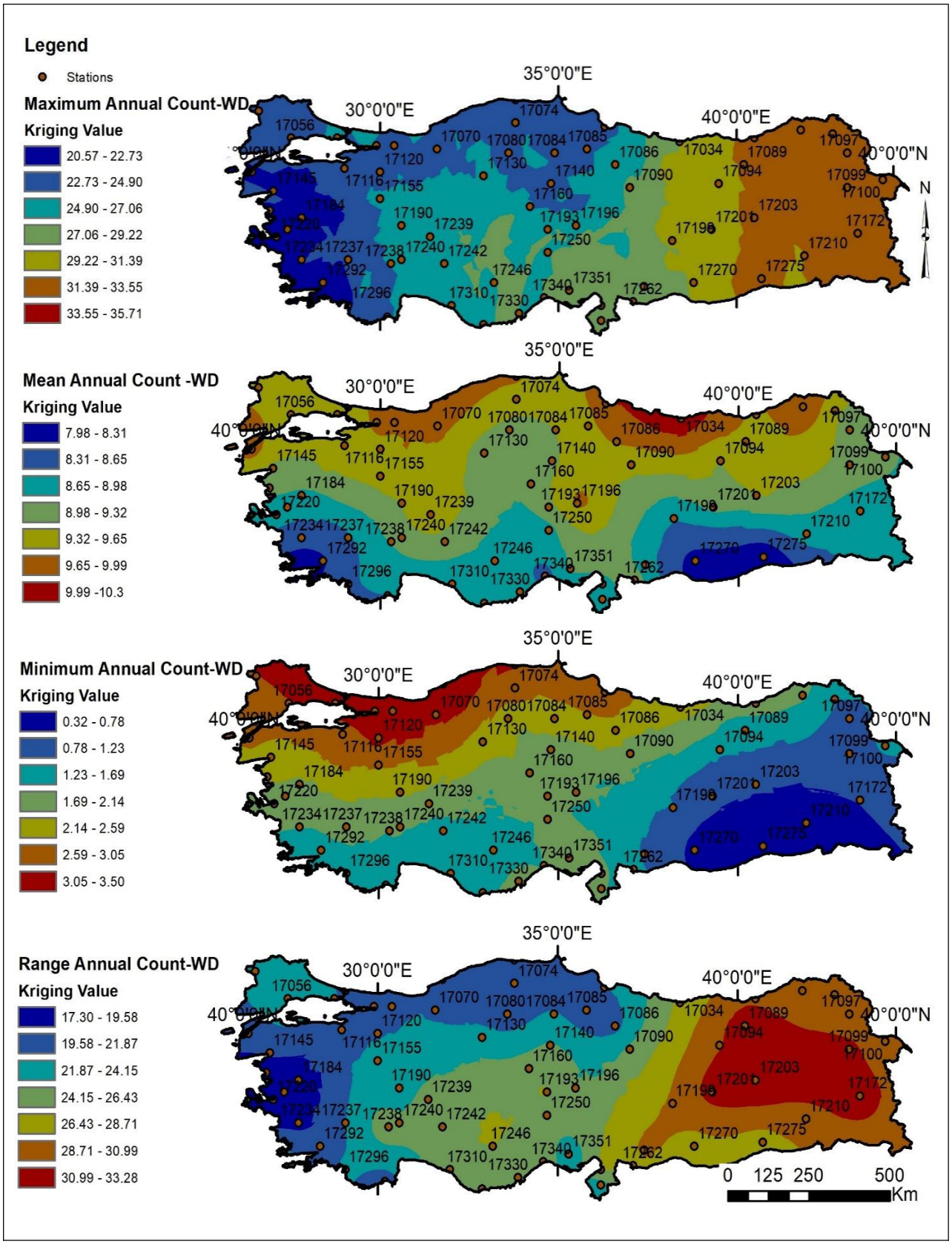

Figure 1; Annual count of Warm Days (WD) changes over Turkey area (in the day)**.**

4. Conclusions

Analysis of warm-days extreme index during 1981 to 2016 over Turkey area showed that there are coherent

patterns of warming trends. Analysis of Man-Kendal trends revealed that the annual number of warm-days has increased by a rate of 1.4 days per decade at the significance level of 95% for the majority (90%) of the study stations. Moreover, the drawn spatial maps for the whole observation period showed that the lowest frequency in the minimum annual count of warm-days has occurred in western areas by a total number of 21 days and its highest has occurred in the eastern area by a total number of 35 days. In other words, the highest frequency in the mean and minimum annual count of warm-days have happened in the northwestern lowland regions. And frequency in the mean and minimum annual count of warm-days have decreased toward lower latitudes in the eastern mountainous regions. Finally, the highest range of differences between the annual count of maximum and minimum records for the warm days has occurred in the eastern regions which are characterized by high mountains and its lowest range has happened in the western and northern coasts. Therefore, it is worthwhile to note that increased moisture content of the atmosphere favors stronger warm-days events, thus increasing the risk of human health diseases, especially for coastal regions. Because of the importance of changes observed on warm-days occurrences, these results can be useful in planning regarded to potential impacts on health, environment.

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