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Trends and changes in tropical and summer days at the Adana Sub-Region of the Mediterranean Region, Southern Turkey

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ABSTRACT

In this study, the long-term variability and trends of the annual and seasonal numbers of summer and tropical days of the Adana Sub-region were investigated using nonlinear and linear trend detection tests for the period 1960–2014 at 14 meteorological stations. The results suggest that the annual number of summer and tropical days was generally below the long-term average through to the end of the 1980s. In particular, positive anomaly values could be observed at all stations between the years 1993–2014. With respect to the Kruskal-Wallis homogeneity test, the significant breaking date was 1993. The rapid rise of the annual number of summer (tropical) days after this year led to the inversion of the negative trends observed from 1987 to 1992 into positive ones. The increasing trend is statistically significance at 0.01 level in Yumurtalık, Mersin and Antakya for the annual number of summer and tropical days. Dörtyol, İskenderun and Elbistan were significance at 0.01 level for tropical days. The largest positive anomalies of the summer of 2010 are observed in coastal vicinity (Mersin, Yumurtalık and İskenderun). This indicates that these settlements underwent a long-term warm period and thermal conditions due to increasing temperatures in the spring and summer months. The same conditions are found in high inner areas (Göksun and Elbistan) for tropical days. It is noticed that a tendency for greater warming occurred at stations located above 1000 m in the sub-region. The average number of warm days will increase 2-days per 100-years in southern part of the sub-region. The increasing trend in summer temperatures can be considered a potential risk, notably for human health and for economic and crop losses in the Adana Sub-region, including Çukurova, one of the most important agriculture areas of Turkey.

1. Introduction

Changes in climate are important for nature as they can affect population abundance and lead to shifts in the range distribution, invasion and extinction of species (Humphries et al., 2002; Parmesan and Yohe, 2003; Root et al., 2003; Thomas et al., 2004). Over the past 30 years, any single weather event could be omitted or added to the record without altering the long-term trend in weather extremes and the statistical relationship between that trend and the rise in global temperatures (Huber and Gulledge, 2011). However, extreme temperatures are emphasized in studies in many areas due to their effect on agriculture, water resources, industry, environment, natural systems and human health (Lafta and Lorenzen, 1995; Adams et al., 1998; Easterling et al., 2000; Welbergen et al., 2008; Kang et al., 2009; McGlone et al., 2010; Lobell et al., 2012; Zwiers et al., 2013; Hatfield and Prueger, 2015). In addition, extreme climatic events such as waves of cold and warm air, extreme precipitation and droughts directly affect human life. In the Middle East, climate change coupled with population growth is likely to reduce per capita water resources considerably, resulting in major social, economic and environmental change (Chenoweth et al., 2011).

Therefore, the classification of extreme events, impacts and disasters may be affected by the measured physical attributes of weather or climatic variables or the vulnerability of social systems (Gönençgil and Acar Deniz, 2016). Because records show an increase in the global mean temperature between 0.4 °C and 0.8 °C in the last 100 years (IPCC, 2007), studies of extreme temperature events have attracted the interest of the scientific community (Burić et al., 2014). Statistics show that not only the mean values of climatic elements (temperature and precipitation) but also the frequency and intensity of these elements have changed, due to the additional atmospheric greenhouse effect from the last quarter of the 19th century (Klein Tank and Können, 2003; Alexander et al., 2006; Erlat and Yavaşlı, 2009). Climatology of upper air temperature in the Eastern Mediterranean region has been studied by Philandras et al. (2015). Their findings have given evidence that air temperature is increasing at a higher rate in lower/middle troposphere

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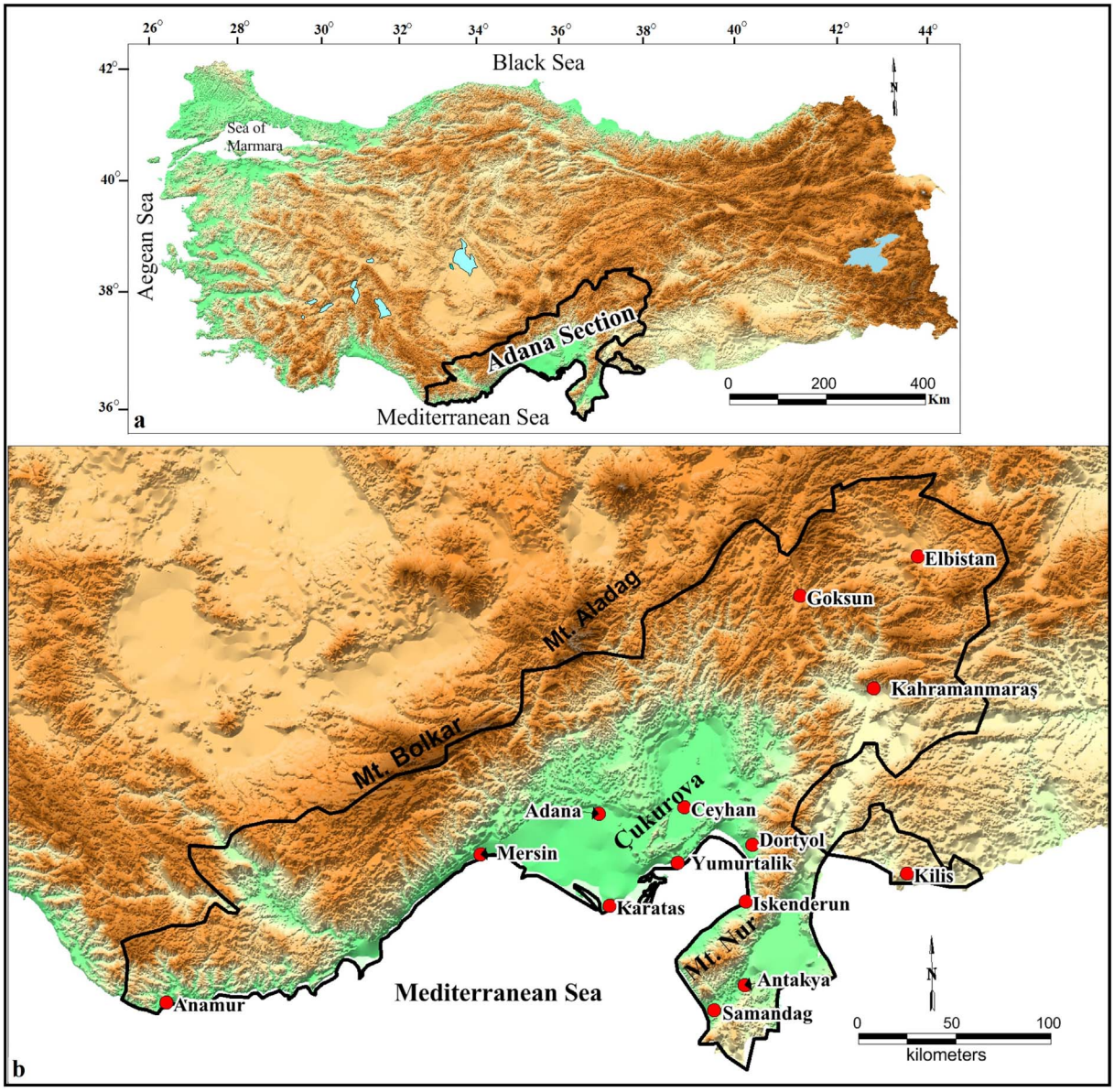

Fig. 1. (a) Location of study area, and (b) meteorology stations.

against upper, and this is very likely due to increasing greenhouse gas concentrations. Thus, trends for extreme events are recognized as an important indicator of climate change. The most significant effect of the re-enforcement of the natural greenhouse effect by anthropic emissions is the positive radiative alteration to the energy balance of the Earth and thus warming of the Earth's climate (Türkeş, 2012).

Although Türkeş et al. (1996) found significant cooling trends for maximum temperatures at many stations in summer and autumn, it is remarkable that these trends changed after 1992, especially during the warm period of the year (Türkeş et al., 1995; Türkeş and Sümer, 2004; Türkeş, 2012). Significant changes, particularly in extreme daily air temperatures (e.g., maximum and minimum temperatures, tropical and summer days) began to appear in the 1990s. The decreases in the number of frosty and snowy days occurred in the Eastern Mediterranean Basin and Turkey in these years (Türkeş, 2012). An increasing trend of daily air temperature extremes in the warm period became more frequent than in cold periods relative to daily air temperature extremes beginning in the early 1980s (Toros, 2012). Cooling trends for the mean and maximum temperatures weakened (Türkeş et al., 2002) while warmer summers, maximum temperature anomalies, and a rising trend in daily temperatures were detected in the Mediterranean Basin (Kutiel and Maheras, 1998; Türkeş and Sarış, 2007; Brunet et al., 2007; Tayanç et al., 2009; Brunetti et al., 2009; Almazroui et al., 2014). Turkey is among the countries significantly affected due to its geographical position. Numerous studies have been carried out on extreme temperature trends and atmospheric circulation throughout the Mediterranean Basin (Türkeş, 1995; Kadıoğlu, 1997; Tayanç et al., 1997; Türkeş and Erlat, 2005; Brunet et al., 2007; Efthymiadis et al., 2011; Karabulut, 2012; İyigün et al., 2013; Kostopoulou et al., 2014). Erlat and Yavaşlı (2009) examined variations and trends for the annual number of tropical and summer days for 10 stations in the Turkish Aegean Region over the period 1939–2008, detecting a significant increasing trend in all stations since the second half of the 1970s. This shows that daytime temperatures are increasing and thermal conditions are becoming hotter in the Aegean region during the warm months of the year (Erlat and Türkeş, 2013). A similar study (Erlat and Türkeş, 2013) at 97 stations in Turkey showed an increasing trend of summer and tropical days between 1950 and 2010 significance at 1% level. Increased frequency and duration of warm events was confirmed in most results.

Kostopoulou et al. (2014) suggested that the spatial distribution of recent temporal trends in temperature indicates a strong increase in