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Anthropogenic signals in Iranian extreme temperature indices

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ABSTRACT

We analyzed spatial and temporal patterns in temperature extremes from 31 stations located throughout Iran for the period 1961 to 2010. As with many other parts of the globe, we found that the number of days (a) with high maximum temperatures was rising, (b) with high minimum temperatures was rising, and (c) with low minimum temperatures was declining; all of these trends were statistically significant at the 0.05 level of confidence. Population records from 1956 to 2011 at the station locations allowed us to reveal that the rate of human population growth was positively related to the increase in the number of days with high maximum temperatures and negatively related to days with low maximum temperatures. Our research shows a number of identifiable anthropogenic signals in the temperature records from Iran, but unlike most other studies, the signals are stronger with indices related to maximum, not minimum, temperatures.

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1. Introduction

There is general consensus in the climate science community regarding the general increase in global mean surface temperatures since the later part of the 19th century. Specifically, the observed temperatures recorded over the last three decades show a successive increase, with the decade of the 2000s as the warmest on record (Stocker et al., 2013). The analysis on long term surface level observations at the global scale indicate a warming of 0.85 [0.65 to 1.06]°C during 1880–2012, ≈0.89 [0.69 to 1.08]°C during 1901–2012, and ≈0.72 [0.49 to 0.89] °C during 1951–2012 based on three independently-produced data sets (Stocker et al., 2013). However, there are substantial temporal variations in these trends that are caused by local level teleconnections such as El Niño Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO), as well as the recently observed global warming hiatus since 1998 (Kosaka and Xie, 2013). Other than temporal variations, there are substantial regional variations in the trends in temperatures driven by land use land cover changes including the role of urban heat island (UHI), deforestation, agriculture-related irrigation effects, as well as other anthropogenic activities (Stocker et al., 2013).

One of the important aspects of long term temperature trends is the occurrence of extreme temperatures. The results from a recently published report on extreme events by Seneviratne et al. (2012) indicated an overall decrease in cold extremes and increase in warm extremes since the middle of the 20th century. For instance, Donat et al. (2013a) found a significant warming of both maximum (TX) and minimum (TN) temperatures over global land areas since 1950. Additionally, a greater shift in the distribution of nighttime temperatures compared to the daytime temperatures was observed in several studies (Ballester et al., 2010; Simolo et al., 2011; Donat and Alexander, 2012; Hansen et al., 2012). However, there are substantial variations in the overall trends and the confidence levels associated with those trends. For instance, in the Middle East, there is medium confidence in the increased occurrence of daytime TX above the 90th percentile and nighttime TN above the 90th percentile (Donat et al., 2013b; Zhang et al., 2005). There is also medium confidence in the increasing trends observed in the incidences of heat waves and warm spells in the Middle East (Perkins et al., 2012; Donat et al., 2013a).

Many papers have appeared in *Atmospheric Research* in the past few years on the topic of trends in extreme temperatures. Several have reported overall warming in Portugal (de Lima et al., 2013), Rajasthan, India (Pingale et al., 2014), and Iran (Araghi et al., 2015a,2015b). However, many others have revealed evidence that the warming of TN have exceeded the warming of TX as reflected in a variety of extreme temperature indices. These findings have come from analyses in Greece (Nastos and Kapsomenakis, 2015), the Philippines (Cinco et al., 2014), northwest China (Deng et al., 2014), Iberia (Fernández-Montes et al., 2012), South America (Rusticucci, 2012), and Modena, Italy (Boccolari and Malmusi, 2013).

In this investigation, we focus on trends in extreme temperatures throughout Iran for the period 1961 to 2010. Over the past decade, a number of important studies have documented the overall warming of the country during the last half century. Ghahraman (2006) investigated the long term trend of mean annual temperature at 34 synoptic stations for the period from 1968 to 1998 and found that at the 0.05 level of significance 44%, 15%, and 41% of the stations had a positive, negative, and zero trend respectively. Rahimzadeh et al. (2009)

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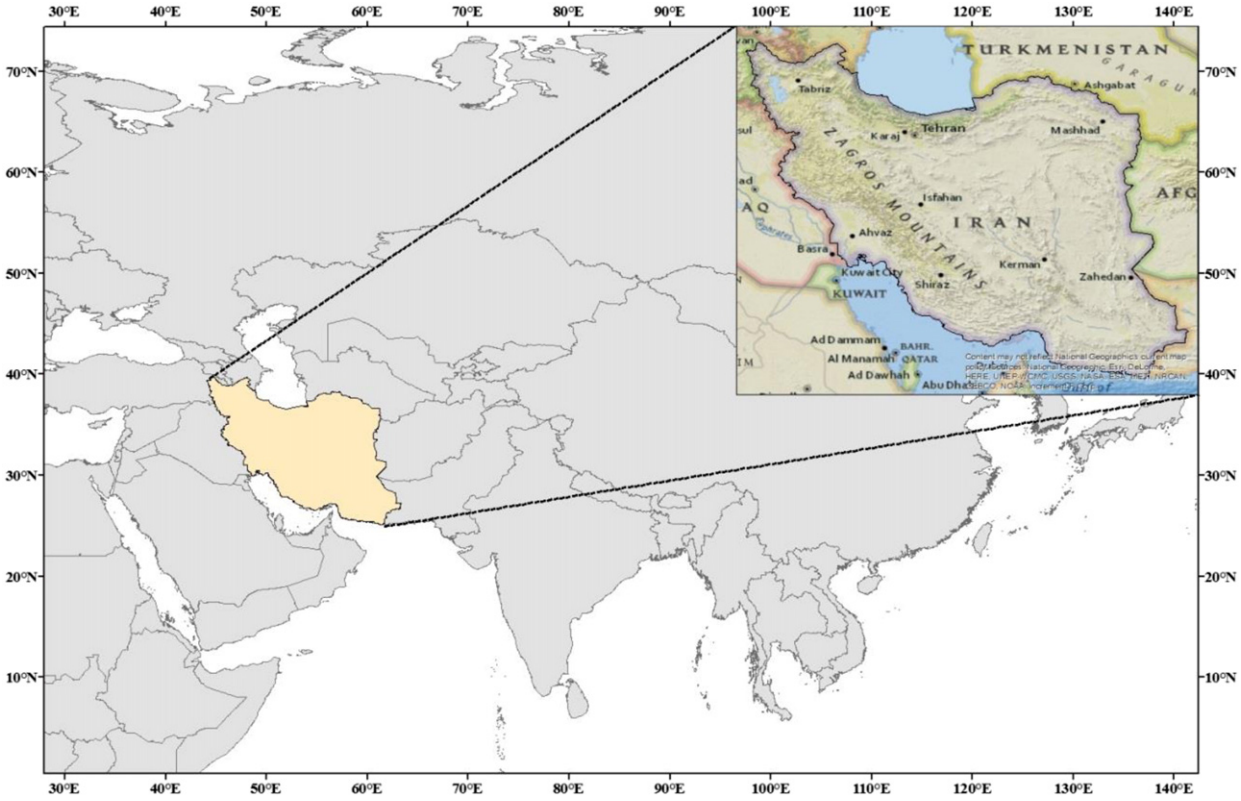

Fig 1. General location and topography of Iran.

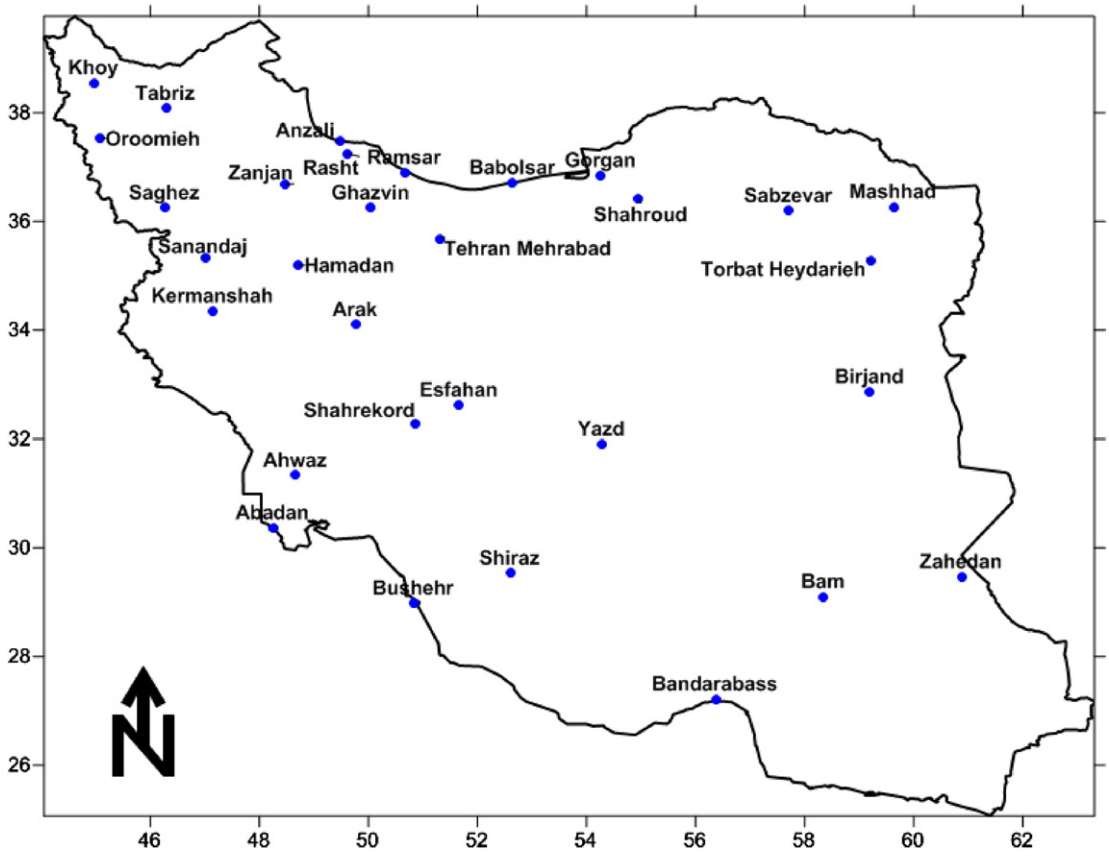

Fig. 2. Location of 31 stations in Iran.

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