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A Study on Trends and Variability in Monthly Temperatures in Antalya Province between the Years 1960 and 2015

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors worked together in all parts of the study such as performing statistical analysis, writing protocol and literature review, and so on. Both authors read and approved the final manuscript.

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ABSTRACT

The purpose of this study is to measure statistically the change in the monthly mean temperatures within the boundaries of Antalya province between the years 1960 and 2015. For this purpose, temperature observation values, obtained from 12 meteorological stations within the boundaries of Antalya province, were analysed using the Mann-Kendall Test and Sen's Slope Estimator. In addition to the values from stations, the mean monthly time series data, generated for all of the boundaries of Antalya province by the Thiessen Polygons method, was also analysed by the methods in question. Antalya province was seen to reflect the typical features of the Mediterranean climate when monthly and seasonal mean temperatures were analysed. The highest temperatures measured in Antalya were 12.5 °C (Kas station) in January and 28.5 °C (Kale) in July. The lowest temperatures were 2.3°C (Elmali station) in January and 23.8 °C (Korkuteli station) in July. The stations, which best represent Antalya province, were Manavgat and Kemer stations in winter and Kale station in summer, according to correlation and Root Mean Square Error (RMSE) test results. Seasonal trend analysis results showed an increase in 10 out of 12 stations in the summer.

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Furthermore 7 of 12 stations showed increasing trends in annual mean temperatures. Negative trends were identified in the Kumluca and Kas stations. There were trends of increase throughout Antalya province only in the months of summer, and no trends in other months, according to the trend test applied to the mean values obtained by the Thiessen method.

Keywords: Temperature; trend analysis; Mann-Kendall test; Antalya; climate change.

1. INTRODUCTION

Climate change is the most studied topic by the scientific community since the beginning of 1900s, and the phenomena that is expected to primarily influence the social environment on a local and global scale [1]. According to IPCC 2014 [2] reports, each period of 30 years has been warmer than the previous 30-year period since 1850. The temperature over land and sea surfaces increased by a mean of 0.85 °C between 1800 and 2015. Ice floes in Greenland and Antarctica are shrinking due to increase in the temperature, and snow-covered fields in the Northern hemisphere are narrowing down in winter. Accordingly, the sea level continuously rose by a mean of 0.19 m in the years between 1901 and 2010.

Today, the impact of climate change on the Earth is forecasted to increase continuously. According to IPCC 2013 [3] reports, the temperature will increase by 0.3-0.7 °C if a great volcanic activity, which will influence the climate to a certain degree, occurred between the years 2016 and 2035. Temperature will increase by 0.3-3.1 °C in the years between 2081 and 2100 compared to the period between 1986 and 2005, according to long-term projections. This increase will bring further reduction in glacier areas and a rise in sea level.

Local and global analysis of temperature is a very important issue, and many researchers have conducted studies on temperature changes in the context of climate change [4]. Studies related to temperature trends in Europe [5-6], Spain [7], Italy [8-9], Switzerland [10], Scandinavia [11], Germany [12-13], France [14], Romania [15], the USA [16], Canada [17], Brazil [18], Morocco [19], China [20], and Australia [21], in different regions of the world.

Several studies were also conducted in Turkey on temperature trend analysis. As studies covering the whole of Turkey [22-23-24] were carried out, research on particular regions, such as Kahramanmaraş [25], the Seyhan River Basin [26], the Central Anatolia Region [27], the South-eastern Anatolia Region [28], the Aegean Region [29], Tokat [30], and Göksun [31], were also conducted in Turkey.

The Mann-Kendall (MK) test [32-33], as one of the non-parametric tests, is widely used in analysing trends in hydro-meteorological data, such as current [34], temperature [35-36] and precipitation [37-38]. The reason behind using non-parametric tests more commonly in climate research is that they are more suitable to the application of data which does not have a normal distribution [39]. MK organizes data in a test time series with the help of a function and doesn’t works with the data itself, but with the series it has formed. It also has a limited sensitivity for outliers.

The aim of this study was to determine trends in monthly mean temperature data obtained from meteorological stations located in Antalya province between the years 1960 and 2015 with the help of MK and Sen’s Slope Estimator (SSE) tests. The mean temperature data was produced for Antalya province and a different analysis was conducted with the help of Thiessen polygons as trend analyses were conducted on station-by-station basis. The degree of influence of climate change in temperatures of Antalya province was attempted to be determined in this way.

2. DATA AND METHODS

2.1 Study Area

The study area is the province of Antalya located in the southwestern part of Turkey (Fig. 1). The population of Antalya is 2,222,562 as of 2014 [40] and its surface area is approximately 21,000 km^2. It is the 6^{th} largest city in Turkey according to surface area. A large part of the provincial land is covered by the Western Taurus Mountains.

The characteristics of the Mediterranean climate are apparently seen in Antalya province. While summers are hot and dry and winters are mild and rainy, the temperatures in winter are lower in inland areas depending on the elevation. The annual mean temperature is 16.62 °C, the coldest month is January with a temperature of 7.06 °C, and the hottest month is July with a temperature of 26.49 °C, according to results obtained by the examination of long-term data between the years 1960 and 2015. The annual rainfall of Antalya is around 1,177 millimetres, and the season with the most rainfall is the winter with 54.2 %; the season with the least rainfall is the summer with 0.8 % [41].

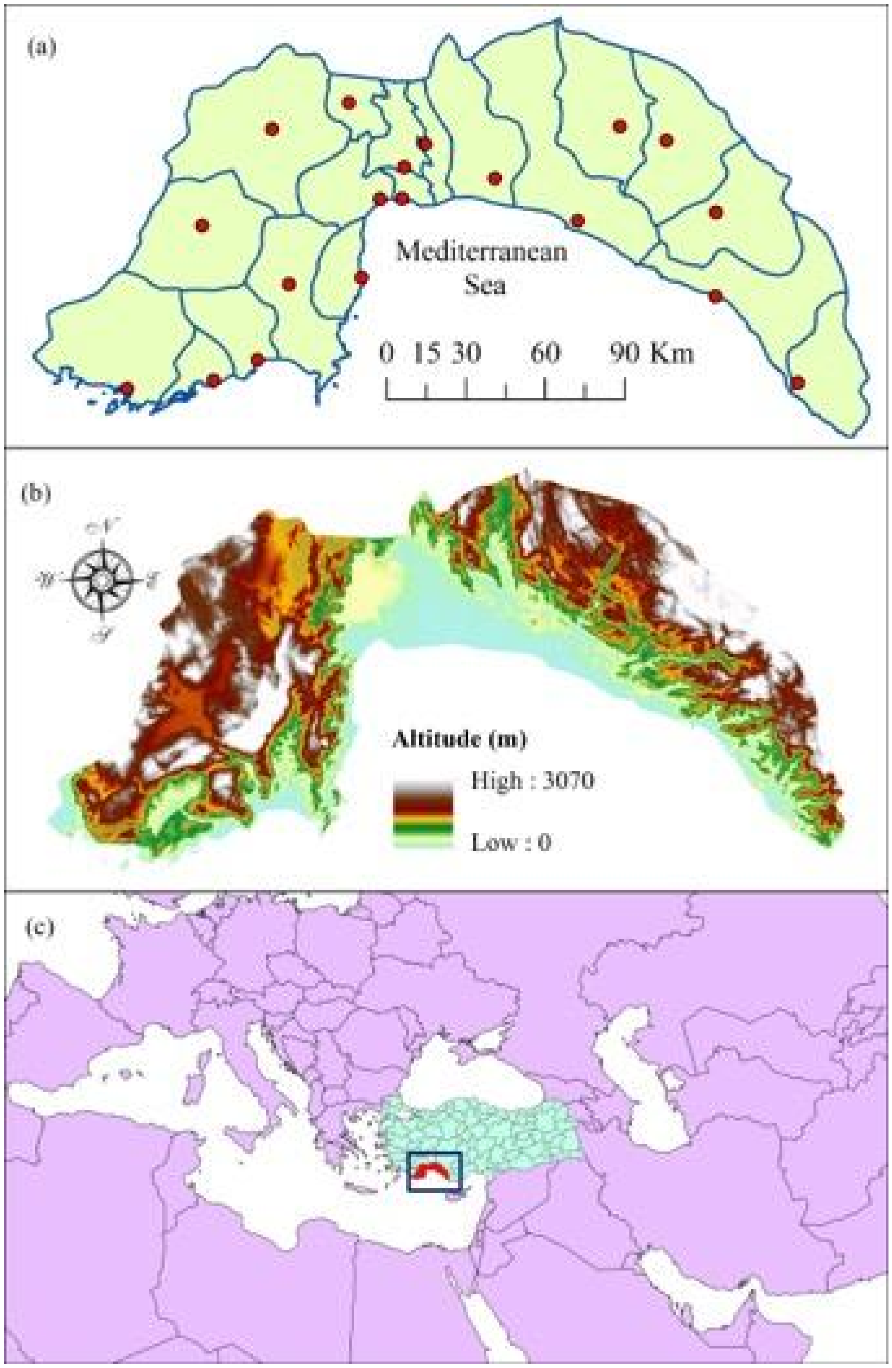

Fig. 1. Study area, Antalya province

An important part of Antalya province is covered with forests consisting of coniferous trees (Fig. 2). Forests with coniferous trees are common everywhere except residential areas and lands devoid of vegetation located on mountain summits, and they occupy 44.5% of the total land. Bare areas also occupy large spaces in high elevations (14 %). The city of Antalya is one of Turkey's 10 largest metropolitan areas and is located in the middle of the study area. District centres are mostly located on the coastline, and only a few of them are located on the plains or on mountain ranges away from the coast. Antalya province has 19 districts and there are 20 urban settlements together with the city centre. However, the ratio of residential areas to the total area of the province is only 3.4 %. Although Antalya province is highly suitable for agriculture in terms of climate conditions, the ratio of agricultural lands to the total area of the province is only 13.3 % due to topography of the land. Shrubs and herbaceous plants are common due to the climate of the study area, and they occupy 24.2 % of the land. The plains are usually narrow areas in the coastal band, and greenhouse cultivation is a very common activity in these areas. Water-covered areas form 0.6 % of the land.

2.2 Data

The monthly mean temperature data that belongs to 12 meteorological stations located within the boundaries of Antalya province between 1960 and 2015 (56 years) were analysed in this study (Table 2). Even though there are 27 meteorological stations in total within Antalya province, the reason for selecting 12 of them was the inability to obtain 56-year long data from all stations. The establishment of some stations is recent, some stations were established long ago but they began to be used after a certain period, and some could not record for a long time due to technical malfunctions.

2.3 Thiessen Polygons

Propounded by climatology expert Alfred Thiessen in 1911, this technique is the formation of polygons by combining points that are situated on a plain with the nearest observation point to themselves [42]. Thiessen polygons, formed in accordance with the proximity criterion, is extensively used in research related to climate [43-44-45]. Thiessen method is simply described as:

$$W_i = \frac{A_p}{A} \tag{1}$$

W_i: weighted area of Thiessen polygons

A_P: The area of Thiessen polygons

A: Total study area

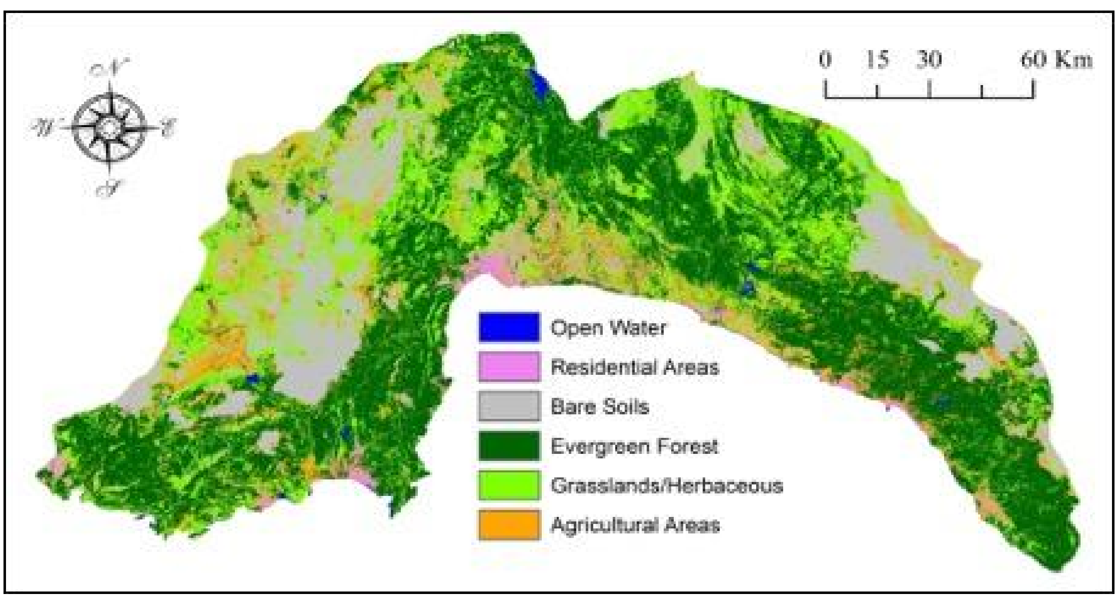

Fig. 2. Land use/land cover map of Antalya province

After the application of this formula, the mean temperature of each polygon is calculated by multiplying the temperature value of polygons with the weighted mean. The mean temperature of the entire study area is calculated using the following formula after finding the mean temperature of all polygons:

$$P = \sum_{i=1}^{n} W_i P_i \quad (2)$$

P: The areal mean temperature of the study area

P_i: Temperatures of meteorological stations within Thiessen polygons

n: Number of total Thiessen polygons

In this study, Thiessen polygons were formed in a way to cover the entire province of Antalya within the geographic information systems (GIS) environment with 12 meteorological stations (Fig. 3). Then the monthly mean time series data, representing Antalya province, was created for a 56-year period with the help of these polygons. The coefficient value for each station was determined by the ratio of the polygon where the station is located to the provincial area. These coefficient values were multiplied by the observation values obtained from the stations, and then the monthly mean temperature values, representing the entire province of Antalya, were obtained by adding the values acquired. However, a trend analysis test was conducted individually for each station located within the boundaries of Antalya.

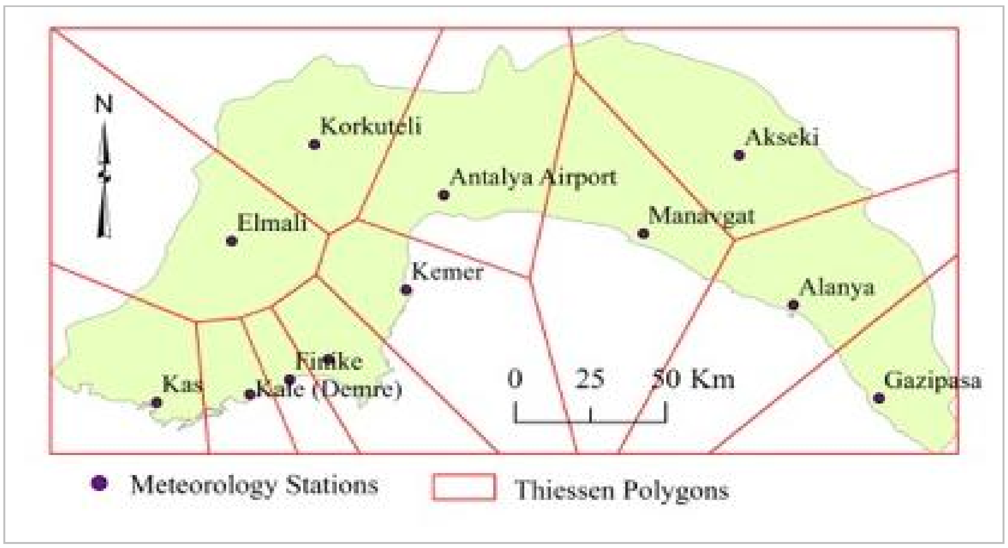

Fig. 3. Thiessen polygons created using meteorological stations

Table 1. Meteorological stations that are located within the boundaries of Antalya and have monthly mean temperature data

Station No	Station name	Sub-Province	Latitude	Longitude	Altitude (m)
18047	Akseki	Akseki	37.0468	31.7971	1063
17310	Alanya	Alanya	36.5507	31.9803	6
17302	Antalya Airport	Yesilkoy	36.9063	30.7990	64
17300	Elmali	Elmali	36.7372	29.9121	1.095
17952	Finike	Finike	36.3024	30.1458	2
17974	Gazipasa	Gazipasa	36.2715	32.3045	21
17970	Kale (Demre)	Kalecik	36.2421	29.9790	25
17380	Kas	Kas	36.2002	29.6502	153
17953	Kemer	Kemer	36.5942	30.5672	10
17926	Korkuteli	Korkuteli	37.0565	30.1910	1.017
17951	Kumluca	Kumluca	36.4636	30.2978	60
17954	Manavgat	Manavgat	36.7895	31.4410	38

2.4 Mann-Kendall and Sen Trend Tests

Generally used for determining trends in hydro-meteorological time series, the Mann-Kendall test, also known as the "Kendal Tau Test", is a non-parametric trend analysis test [46-47-48]. This test has been used widely in many hydro-meteorological studies [49-50-51]. The Mann-Kendall test is calculated as:

$$\sum_{i-1}^{n-1} \sum_{j=i+1}^{n} sgn(x_j - x_i) \quad (3)$$

Where *n* is the number of points (station), x_i and x_j are the data belonging to time series *i* and *j* (*j*>*i*), *sgn* (x_i - x_j) is the sign function as:

$$sgn(x_j - x_i) = \begin{cases} 1, & x_i < x_j \\ 0, & x_i = x_j \\ -1, & x_i > x_j \end{cases} \quad (4)$$

The variance is calculated as:

Var (S) =

$$\frac{n(n-1)(2n+5) - \sum_{k-1}^{l} t_k\,(t_k-1)(2t_k+5)}{18} \quad (5)$$

Where *n* is the number of observations and *l* is the number of tied groups. The summery sign indicates the summation of all groups and *t* is the extent of time series data. t_k denotes the number of ties in extent *k*.

Data, which we obtained from the Turkish State Meteorological Service and received from the stations specified in Table 1 between 1960 and 2015, was converted into time series that may be subjected to the MK test, and then the test was conducted. Tests were applied both to the mean value representing Antalya province and the station values individually. The study also showed in what way the slopes were formed in trends of time series using Sen's Slope Estimator. Sen's Slope Estimator can be calculated as:

$$Q_i = \frac{x_j - x_k}{j-k} \text{ for } i=1,2,...N,(j>k)$$

Where x_j and x_k are data values in time *j* and time *k* respectively.

N value is found with *N* = n (n-1)/2, and the median of *N* and Q_i values is used to find Sen's trend slope value.

3. RESULTS

3.1 Monthly Mean Temperatures

The effect of latitude on temperature values is very clear when looking at 56-year means of meteorological stations within the boundaries of Antalya province (Table 2). The coldest month was January and the hottest month was July within Antalya province, since it is situated in the Northern hemisphere. Temperatures in the month of January were close to each other in all the stations on the coastline, and the stations where the temperature was the highest were Kas (12.5 °C) and Alanya (11.8 °C). Winter temperatures were also above 10 °C, apart from Kemer, at the stations situated on the coastline. They were very low in the Akseki, Elmali and Korkuteli stations located at inland areas as compared to coastal regions, at 3.2, 2.3 and 2.6 °C, respectively. Here, the aspect of these stations should be taken into account together with the effect of slope. Temperatures in July were over 27 °C in 8 of the 12 stations, where the highest temperature recorded was 28.5 °C. While the coldest month throughout Antalya province was January with 7.8 °C, the hottest month was July with 26.5 °C, when looking at the mean temperatures obtained by the Thiessen method. Finally, the influence of the Mediterranean climate was seen to be dominant in the temperatures of Antalya province, except in high areas, when looking at the monthly mean temperatures within the boundaries of the province.

When looking at the mean temperature trends between 1960 and 2015, a decrease was seen from 1960s up to the 1990s, and it increased after that (Fig. 4). The temperature difference between meteorological stations on the coastline and those in mountainous areas can clearly be seen in the graph in line with the tables 2. While Akseki station stood out as the place with the highest temperature, Alanya drew attention as the hottest place in Antalya after 1995. Large fluctuations occurred in temperatures in the early 1990s.

3.2 Analysis of Temperature Anomalies

Temperature anomalies were conducted with the purpose of determining the differences between monthly mean temperatures of stations and the means obtained by the Thiessen method (Fig. 5). For this purpose, Thiessen values for the 56-year period were subtracted from the observation values of the stations. Values under zero in these graphs indicated that the Thiessen values were higher than observation values, and values above zero indicated that the Thiessen values were lower than observation values. As can be seen from the figure, anomaly values were below 0 only in 4 of the 12 meteorological stations. Fluctuations in the anomaly values of Kas station indicated instability in temperatures. Alanya and Finike stations attracted attention as the stations where the anomaly values were closest to each other. Sharp declines were seen in all stations in the early 1990s. There were wide gaps in the data of Akseki, Kale, Kemer and Kumluca stations.

Table 2. Monthly mean temperature values of 56 years belonging to meteorological station within the boundaries of Antalya province. The Antalya mean obtained by Thiessen polygons are added at the end of the table

Stations	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
Akseki	3.2	3.7	6.4	10.8	15.7	20.7	24.3	24.1	20.4	15.1	8.9	4.9
Alanya	11.8	11.9	13.8	16.9	20.9	24.9	27.6	27.8	25.2	21.1	16.5	13.3
Antalya Air.	9.8	10.3	12.6	16.0	20.4	25.3	28.3	28.0	24.5	19.9	14.8	11.3
Finike	11.1	11.4	13.3	16.5	20.7	25.1	28.0	27.7	24.3	20.0	15.6	12.5
Gazipasa	10.8	10.8	12.6	15.8	19.8	24.4	27.2	27.2	24.2	19.9	15.3	12.1
Kale (Demre)	10.1	10.3	12.4	16.0	20.6	25.2	28.5	28.3	24.5	19.4	14.4	11.4
Kas	12.5	12.5	14.1	17.1	21.0	25.1	27.9	28.3	25.7	21.6	17.3	14.0
Kemer	6.5	7.0	9.5	13.8	18.3	23.2	26.3	26.1	22.2	16.6	11.2	7.5
Korkuteli	2.6	3.4	6.6	10.7	15.7	20.6	23.8	23.2	19.0	13.5	7.7	4.0
Kumluca	10.2	10.6	12.8	16.3	20.2	24.8	27.6	27.5	24.5	19.9	15.1	11.6
Manavgat	10.6	10.9	12.9	16.2	20.3	24.9	27.9	27.8	24.7	20.4	15.4	12.0
Elmali	2.3	3.4	6.9	11.3	16.1	20.9	24.3	24.0	19.8	14.2	8.5	4.1
Thiessen P.	**7.8**	**8.3**	**10.8**	**14.4**	**18.8**	**23.4**	**26.5**	**26.4**	**22.8**	**18.1**	**12.9**	**9.4**

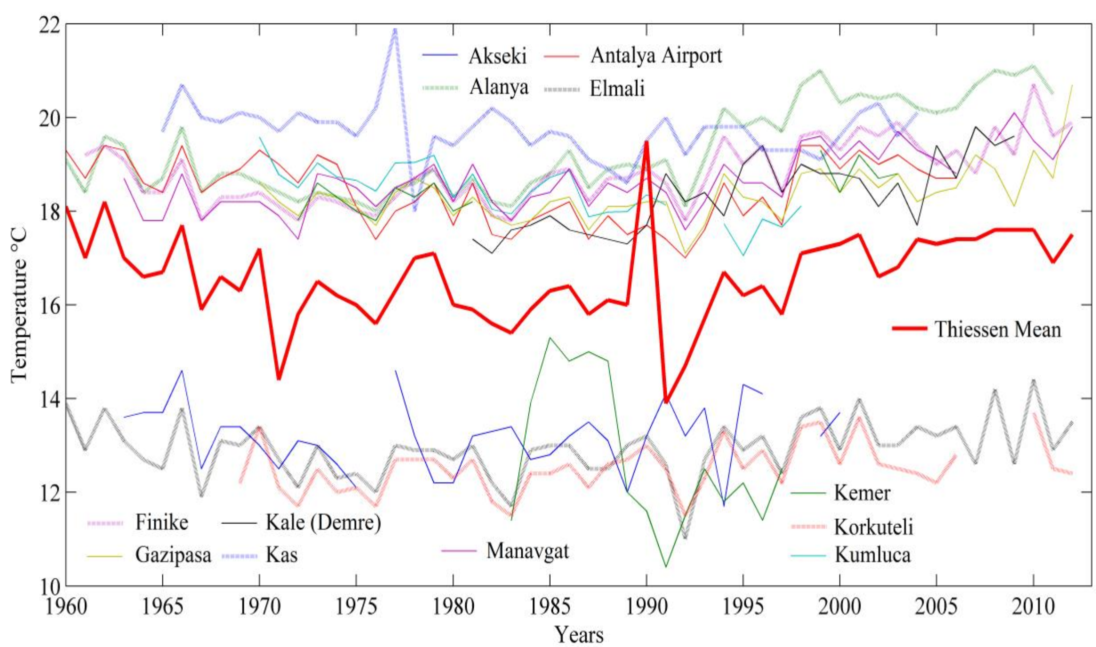

Fig. 4. Variation of annual mean temperatures for stations located in the study area between the years of 1960 and 2015

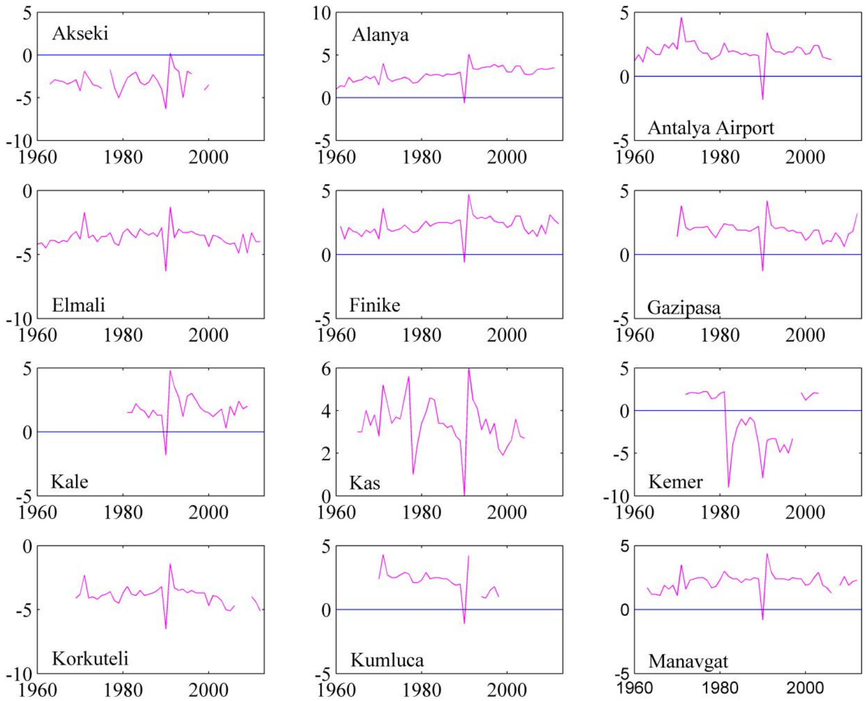

Fig. 5. Temperature anomaly values (°C) within the boundaries of Antalya province

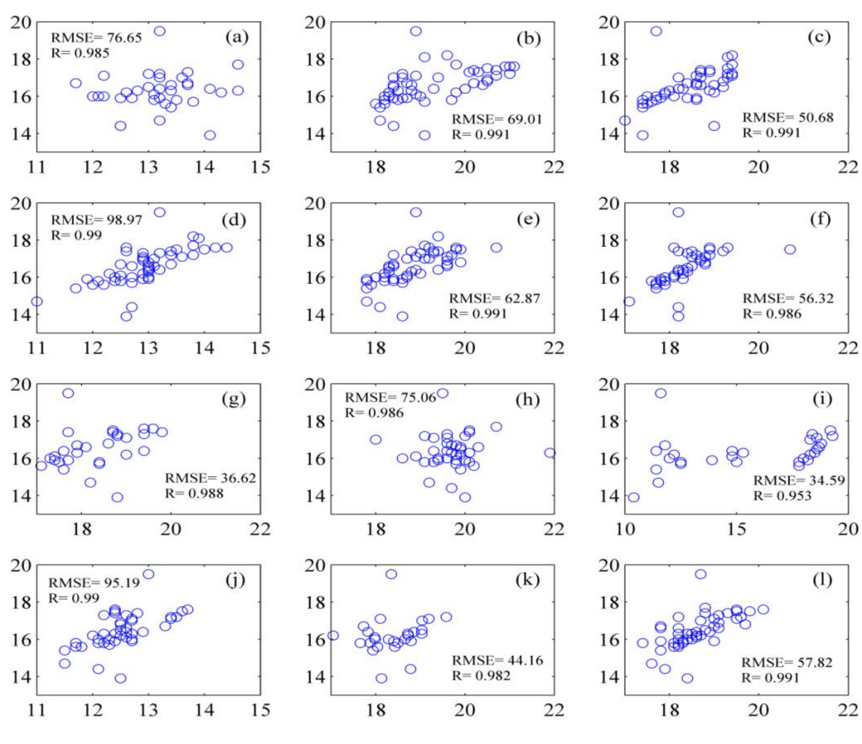

Fig. 6. Data distribution between station values (x-axis) and Thiessen values (y-axis)
Stations are: a-Alanya, b-Akseki, c-Antalya Airport, d-Elmali, e-Finike, f-Gazipasa, g-Kale (Demre), h-Kas, i-Kemer, j-Korkuteli, k-Kumluca, and l-Manavgat.

3.3 Determining the Similarity between Temperature Values

The relationship between the observation values measured at the stations and Thiessen values was also analysed by Correlation and Root Mean Square Error (RMSE) tests, and it was attempted to discover which station represented better the entire area of Antalya province. the general of Antalya province better. The station where the correlation value was the highest and RMSE value was the lowest was not thought to describe the study area the best. Correlation values were very high for all stations, and they were very close to 1 (Fig. 6). It was 0.99 in 10 of the 12 stations. Large differences were seen in RMSE values. The station with the highest RMSE was Elmali with 99, and the station with the lowest was Kale with 36.6 in annual mean temperature. It was difficult to say whether there was a parallelism between Thiessen values and station values when considering the scatter distribution. Uneven distribution was seen especially in the Alanya, Kale and Kas stations.

According to the results of seasonal tests, the stations where the correlation values were the highest were: Manavgat in winter; Manavgat and Elmali in spring; Kas in summer; and Finike in autumn (Table 3). The stations where RMSE values were the lowest were: Kemer in winter; and Kale (Demre) in spring, summer and autumn. Temperature differences were seen to increase in winter in Antalya province when considering that RMSE values were higher in winter and lower in summer.

3.4 Results of Seasonal and Annual Trend Analyses

Results of seasonal and annual trend analyses were conducted both for the entire data set (1960-2015) (Table 3) and the periods of 1960-1979 (Table 4), 1980-1999 (Table 5) and 2000-2015 (Table 6). According to the results of trend analysis conducted using all data sets, while a strong trend of 1 % was seen in summer for Antalya province in temperatures produced by Thiessen method, no trend was seen in other

Table 3. Correlation and RMSE test results between observation values obtained from stations and Thiessen values

Correlation	Annual	Winter	Spring	Summer	Fall	Record length
Alanya	0.99	0.79	0.65	0.58	0.49	56 years
Akseki	0.99	0.71	0.78	0.61	0.56	46 years
Antalya Airport	0.99	0.80	0.73	0.47	0.61	46 years
Elmali	0.99	0.85	0.80	0.64	0.66	56 years
Finike	0.99	0.86	0.78	0.62	0.70	56 years
Gazipasa	0.99	0.73	0.55	0.58	0.28	44 years
Kale (Demre)	0.99	0.65	0.60	0.52	0.54	29 years
Kas	0.99	0.29	0.60	0.69	0.57	39 years
Kemer	0.95	0.55	0.29	0.49	0.53	16 years
Korkuteli	0.99	0.79	0.79	0.67	0.57	45 years
Kumluca	0.98	0.65	0.35	0.20	0.35	28 years
Manavgat	0.99	0.88	0.80	0.63	0.55	50 years
RMSE	**Annual**	**Winter**	**Spring**	**Summer**	**Fall**	**record length**
Alanya	76.6	28.4	17.4	11.9	20.5	56 years
Akseki	69.0	26.9	19.5	14.1	18.2	46 years
Antalya Airport	50.7	14.5	13.1	14.9	14.0	46 years
Elmali	99.0	33.2	20.7	16.0	23.6	56 years
Finike	62.9	21.6	15.1	12.4	14.3	56 years
Gazipasa	56.3	19.1	10.6	9.1	13.5	44 years
Kale (Demre)	36.6	10.0	8.5	8.0	7.9	29 years
Kas	75.1	26.9	16.9	11.1	21.9	39 years
Kemer	34.6	9.6	8.8	10.4	11.3	16 years
Korkuteli	95.2	29.2	20.8	17.5	25.8	45 years
Kumluca	44.2	14.4	11.3	11.4	12.9	28 years
Manavgat	57.8	18.7	13.3	12.1	16.4	50 years

seasons or annual values. Very strong positive trends for each period of the year were formed in the Alanya and Kale stations. Again, negative trends were observed in the Kas and Antalya Airport stations in winter. Positive trends were available in 8 of the 12 stations in summer and 7 of the stations for annual temperatures. Three negative trends occurred in winter and spring respectively.

Fewer trends were seen compared to the 56-year period when examining 20 years and 12 years data sets. annual analyses. Despite being negative and lower, trends occurred in Thiessen values between 1960 and 1979 in all seasons, except spring, and the annual values (Table 4). A total of 14 trends were formed in all the stations during this time, and only one of them was a positive trend. This positive trend belonged to the spring temperatures of Manavgat station. The most number of negative trends were discovered in the annual values and only 1 trend was formed in spring. Trends were not formed for this period due to the lack of data in Kale station.

Alanya station was the place where the strongest positive trends were formed in the period of 1980-1999. Summer, autumn and annual trends in this station were the highest trends in the table (Table 5). 11 out of 20 trends in the table were weak trends of 10 %. The least number of trends were seen in spring as in the previous period. No trend was seen in Antalya Airport, Elmali, Kas and Kumluca stations. The only negative trend in the table was formed in spring in Kemer station.

A very small amount of low-value trends occurred in the period of 2000-2015 due to the very short range of data (Table 6). Only 5 of 10 % trends occurred during this period, and no trends occurred in winter and spring. The only negative trend was formed in autumn at Gazipasa station. Trend analysis in 4 stations did not yield any results due to lack of data.

Table 4. Seasonal and annual trend values for 1960-2015 produced using monthly mean temperature values

Station	Test	Trends				
		Winter	Spring	Summer	Fall	Annual
Thiessen	Z	0.18	0.77	3.32***	0.82	1.57
	Q	0.001	0.009	0.033	0.008	0.015
Alanya	Z	3.10**	4.15***	5.46***	5.56***	5.18***
	Q	0.028	0.039	0.064	0.053	0.048
Akseki	Z	0.91	0.63	2.26*	-0.29	0.91
	Q	0.014	0.006	0.036	-0.005	0.01
Antalya Airp.	Z	-2.04*	-0.66	1.61	-1.64	-1.31
	Q	-0.022	-0.008	0.013	-0.021	-0.011
Elmali	Z	0.94	1.27	3.55***	1.20	2.42*
	Q	0.007	0.009	0.025	0.010	0.014
Finike	Z	0.88	2.65**	6.13***	4.63***	4.38***
	Q	0.007	0.019	0.059	0.037	0.032
Gazipasa	Z	0.06	1.57	4.30***	0.12	2.92**
	Q	0.001	0.012	0.042	0.001	0.016
Kale (Demre)	Z	2.78**	4.15***	5.44***	3.88***	4.90***
	Q	0.058	0.068	0.123	0.085	0.082
Kas	Z	-2.36*	-2.30*	3.63***	-0.76	-1.51
	Q	-0.029	-0.019	0.029	-0.009	-0.008
Kemer	Z	0.36	-2.13*	0.59	-1.31	-0.014
	Q	0.024	-0.058	0.023	-0.055	-0.004
Korkuteli	Z	1.51	1.72	4.91***	2.64**	3.99***
	Q	0.015	0.018	0.056	0.02	0.029
Kumluca	Z	-2.36*	-3.05**	-0.69	-3.34***	-3.50***
	Q	-0.044	-0.055	-0.008	-0.06	-0.04
Manavgat	Z	1.64	3.28**	5.53***	4.20***	5.13***
-	Q	0.012	0.021	0.048	0.037	0.031

Z: Mann-Kendall Test, Q: Sen's Slope Estimator
** Statistically significant trends at 10% significance level.*
*** Statistically significant trends at 5% significance level.*
**** Statistically significant trends at 1% significance level.*

Table 5. Seasonal and annual trend values for 1960-1979 produced using monthly mean temperature values

Station	Test	Trends				
		Winter	Spring	Summer	Fall	Annual
Thiessen	Z	-1.98*	-0.88	-2.50*	-1.98*	-2.30*
	Q	-0.111	-0.042	-0.066	-0.079	-0.075
Alanya	Z	-1.53	-1.82	-2.92**	-1.75	-2.27*
	Q	-0.07	-0.025	-0.058	-0.033	-0.049
Akseki	Z	-1.27	0	-2.69**	-2.70**	-2.63**
	Q	-0.01	0	-0.167	-0.15	-0.088
Antalya Airp.	Z	-1.69	-0.52	-0.91	-2.37*	-2.11*
	Q	-0.06	-0.012	-0.024	-0.091	-0.042
Elmali	Z	-1.33	0.45	-1.75	-1.04	-1.91
	Q	-0.08	0.007	-0.061	-0.033	-0.049
Finike	Z	-2.27*	-1.01	-0.62	-1.69	-2.37*
	Q	-0.083	-0.013	-0.02	-0.065	-0.047
Gazipasa	Z	0.72	-1.79	-0.09	1.43	0.36
	Q	0.08	-0.058	0.0	0.078	0.025
Kale (Demre)	Z	n/a	n/a	n/a	n/a	n/a
	Q	n/a	n/a	n/a	n/a	n/a
Kas	Z	-1.72	0.74	0.98	-0.12	-1.10
	Q	-0.1	0.015	0.031	-0.003	-0.017
Kemer	Z	n/a	n/a	n/a	n/a	n/a
	Q	0.23	-0.01	0.116	-0.033	0.077
Korkuteli	Z	0.93	1.09	0	0.55	1.09
	Q	0.09	0.044	-0.008	0.04	0.039
Kumluca	Z	0.72	0.72	0.09	0.89	1.07
	Q	0.044	0.033	0.011	0.075	0.029
Manavgat	Z	0.54	2.44*	0.124	1.73	1.36
-	Q	0.03	0.033	0.005	0.092	0.042

Z: Mann-Kendall Test, Q: Sen's Slope Estimator
** Statistically significant trends at 10% significance level.*
*** Statistically significant trends at 5% significance level.*
**** Statistically significant trends at 1% significance level.*

Table 6. Seasonal and annual trend values for the periods of 1980-1999 produced using monthly mean temperature values

Station	Test	Trends				
		Winter	Spring	Summer	Fall	Annual
Thiessen	Z	1.20	0.68	2.50*	0.88	1.52
	Q	0.036	0.014	0.088	0.035	0.047
Alanya	Z	2.53*	2.63**	4.12***	4.12***	3.93***
	Q	0.101	0.1	0.155	0.117	0.114
Akseki	Z	2.28*	0.84	2.49*	0.74	1.82
	Q	0.085	0.026	0.083	0.044	0.057
Antalya Airp.	Z	0.88	0.00	1.09	0.32	0.91
	Q	0.039	0.002	0.044	0.007	0.17
Elmali	Z	1.40	-0.42	1.68	0.63	1.33
	Q	0.063	-0.021	0.05	0.029	0.033
Finike	Z	1.75	0	2.81**	3.06**	2.17*
	Q	0.041	0	0.113	0.067	0.06
Gazipasa	Z	0.39	0.28	2.03*	-0.11	1.02
	Q	0.014	0.008	0.044	-0.003	0.014
Kale (Demre)	Z	2.25*	1.44	3.56***	2.43*	3.02*
	Q	0.117	0.05	0.158	0.072	0.113

Station	Test	Trends				
		Winter	Spring	Summer	Fall	Annual
Kas	Z	-0.43	-1.28	1.10	-1.22	-1.04
	Q	-0.018	-0.113	0.058	-0.081	-0.046
Kemer	Z	0.36	-2.13*	0.59	-1.31	-0.14
	Q	0.024	-0.058	0.023	-0.055	-0.004
Korkuteli	Z	1.85	0.52	2.66**	1.40	2.17*
	Q	0.054	0.032	0.072	0.039	0.05
Kumluca	Z	-0.75	0.27	0.07	-1.72	-0.34
	Q	-0.048	0.026	0.008	0.078	-0.012
Manavgat	Z	1.62	0.36	2.34*	0.55	1.72
	Q	0.033	0.008	0.069	0.022	0.035

Z: Mann-Kendall Test, Q: Sen's Slope Estimator
** Statistically significant trends at 10% significance level.*
*** Statistically significant trends at 5% significance level.*
**** Statistically significant trends at 1% significance level.*

Table 7. Seasonal and annual trend values for 2000-2015 produced using monthly mean temperature values

Station	Test	Trends				
		Winter	Spring	Summer	Fall	Annual
Thiessen	Z	1.16	0.18	1.77	0.79	1.77
	Q	0.058	0.017	0.075	0.073	0.033
Alanya	Z	1.10	0.61	1.6	0	1.40
	Q	0.071	0.029	0.065	0	0.05
Akseki	Z	n/a	n/a	n/a	n/a	n/a
	Q	n/a	n/a	n/a	n/a	n/a
Antalya Airp.	Z	n/a	n/a	n/a	n/a	n/a
	Q	-0.017	0.1	-0.156	-0.208	-0.071
Elmali	Z	1.34	0.24	1.41	0.61	1.65
	Q	0.106	0.013	0.104	0.067	0.071
Finike	Z	0.31	-0.06	2.08*	1.40	1.47
	Q	0.04	0	0.079	0.057	0.042
Gazipasa	Z	0.43	0.55	0.86	-2.08*	0.79
	Q	0.048	0.033	0.038	-0.078	0.023
Kale (Demre)	Z	1.04	1.47	2.50*	1.96	2.14*
	Q	0.064	0.071	0.18	0.098	0.093
Kas	Z	1.65	0.06	1.59	1.59	2.08*
	Q	0.11	0.002	0.064	0.085	0.05
Kemer	Z	n/a	n/a	n/a	n/a	n/a
	Q	n/a	n/a	n/a	n/a	n/a
Korkuteli	Z	0.73	0.31	1.47	0.86	1.04
	Q	0.058	0.018	0.151	0.033	0.072
Kumluca	Z	n/a	n/a	n/a	n/a	n/a
	Q	n/a	n/a	n/a	n/a	n/a
Manavgat	Z	0.12	0.73	1.40	0.37	1.16
	Q	0.01	0.031	0.05	0.021	0.04

Z: Mann-Kendall Test, Q: Sen's Slope Estimator
** Statistically significant trends at 10% significance level.*
*** Statistically significant trends at 5% significance level.*
**** Statistically significant trends at 1% significance level.*

While positive trends occur in summer and annual means, no trends were generally observed in winter and spring, as can be seen in Fig. 7. Negative trends occurred in very small numbers and there were 3 negative trends in winter, 3 in spring, 1 in autumn and 1 in annual precipitation.

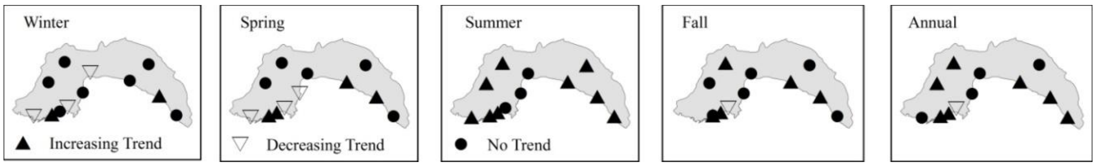

Fig. 7. Rising and falling trends according to seasons and stations where no trends occurred

Table 8. The results of monthly trend analysis for data produced by Thiessen Polygons method

Months	First year	Last Year	n	Test S	Test Q	Significance
Ocak	1960	2015	56	0.002	0.18	
Şubat	1960	2015	56	0.006	-0.48	
Mart	1960	2015	56	0.001	-0.05	
Nisan	1960	2015	56	0.008	0.59	
Mayıs	1960	2015	56	0.022	1.71	
Haziran	1960	2015	56	0.025	2.52	*
Temmuz	1960	2015	56	0.03	3.20	**
Ağustos	1960	2015	56	0.043	2.97	**
Eylül	1960	2015	56	0.015	1.70	
Ekim	1960	2015	56	0.01	0.76	
Kasım	1960	2015	56	0.006	-0.39	
Aralık	1960	2015	56	0.004	-0.28	

3.5 Monthly Mean Temperature Trends

The results of the trend analysis conducted with monthly values using data of 56-years for the period of 1960-2015 were in line with the seasonal trend tests conducted for the same period (Table 8 above). While trends were observed in the summer months of June, July and August, no trends were observed in other months. Trends occurring in July and August were more powerful compared to the month of June. The results of the Sen's Slope Estimator test also confirmed the MK test, and the highest trends occurred again in the months of June and July.

4. DISCUSSION AND CONCLUSIONS

In this study, the monthly mean temperature data of 12 meteorological stations within the boundaries of Antalya province between the years 1960 and 2015 were analysed in terms of their variability, means and trends. These analyses were conducted with the help of a MK test and a SSE test. Test results showed that the greater the sample size, the better the MK and SSE tests caught trends, and thus provided more accurate results [39].

Monthly mean temperatures in stations were analysed in general before the trend tests. The first point that attracted attention in the mean temperatures was that the temperatures on the coastline were higher than the inland areas. The main reason behind the significant low monthly mean temperatures in the Akseki, Elmali and Korkuteli stations located in inland areas compared to the coastal areas was the high elevation of stations located in the inland areas of Antalya. Antalya was seen to reflect the characteristic features of the Mediterranean climate very well in terms of its temperature features. Winter temperatures were generally 10-11 °C, summer temperatures were 27-28 °C, annual mean temperatures at stations in inland areas were 13 °C, and that in coastal stations were 18-19 °C. The different situation in annual mean temperatures manifested itself in anomaly graphs.

Correlation and RMSE tests were performed by the method of comparing time series data obtained by the Thiessen method and representing all of Antalya province and annual and seasonal time series data of stations. Correlation values were found to be very high at all stations for annual temperatures. The station representing Antalya province the best on an annual basis was Kale station according to RMSE values. It could be seen according to the correlation values obtained from seasonal temperatures that Manavgat station was the station that represented Antalya the best in winter and spring, and it could be best represented by Kas station in summer and Finike station in autumn. According to RMSE values, stations representing Antalya the best were Kemer station in winter and Kale (Demre) station in spring, summer and autumn.

Many strong trends emerged using 56 years of data. Strong trends were available in 4 seasons and the annual means at Alanya, Manavgat and Kale stations. Negative trends occurred in all seasons except summer, and in the annual means in Kumluca station. A very strong trend of 1 % was available in summer in 9 out of 12 stations. There were still strong trends of 1 % in annual means in 6 out of 12 stations. Furthermore, trends also occurred in 2 stations, even if it was lower. As a result, there were rising trends in annual mean temperatures in 8 out of 12 stations within Antalya province. It can be concluded based on this that the average temperatures increased throughout Antalya province. Fewer trends occurred in the analysis in which data sets were shortened. This can be shown as evidence that the deficiencies in data sets affected the results of the study. Rising trends attracted attention in summer and trend formation was not observed in other months when looking at the results of the Thiessen monthly trends.

According to the results of the study, temperature rise is a statistical fact in Antalya in summer, this rise will affect summer tourism, forest fires and water resources, and these effects are likely to deepen in the future.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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