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DETERMINATION OF TEMPERATURE VARIABILITIES AND TRENDS IN TURKEY

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Abstract : A comprehensive study has been carried out for Turkey to investigate temperature variabilities and trends in a 50-year period of 1969-2018. Daily temperature data belonging to 174 meteorological stations which was collected from Turkish Meteorological State Service was used in this research. Temporal and spatial variability of temperature have been studied by linear regression, 3-yr moving average and non-parametric Mann-Kendall test. Yearly and seasonally average temperature of each region has been formed from analysis of daily average temperature for this time period. Temperature increase in this recent half century time period is found to be in the Eastern Anatolia Region with a value of 1.74°C/50 years. The regions with the highest seasonal temperature increases are estimated to be the Aegean Region (1.61°C) in autumn, Eastern Anatolia Region (2.37°C) in winter, Eastern Anatolia Region (1.84°C) in spring and Marmara Region in summer (2.79°C). Moreover, yearly temperature trends showed increasing trends at 99% confidence interval in most stations. Increasing trends at 99% confidence interval have been confirmed in most regions from analyzing seasonally and yearly temperature trends.

Keywords: Climate Change, Temperature, Mann-Kendall Test, Trend Analysis, Turkey

Türkiye'de Sıcaklık Değişimleri ve Trendlerin Belirlenmesi

Öz: Türkiye için 1969-2018 yılları arasındaki 50 yıllık süreçte, sıcaklık değişimleri ve eğilimlerini araştırmak için geniş kapsamlı bir çalışma yapılmıştır. Bu araştırma kapsamında, Meteoroloji Genel Müdürlüğü'nden toplanan 174 meteoroloji istasyonuna ait günlük ortalama sıcaklık verileri kullanılmıştır. Yıllık ve mevsimlik ortalama sıcaklıklar, günlük ortalama sıcaklıklardan elde edilmiştir. Sıcaklığın, zamansal ve mekansal değişkenliği; lineer regresyon, 3 yıllık hareketli ortalama ve parametrik olmayan Mann-Kendall testi ile incelenmiştir. Bu son yarım yüzyıllık zaman diliminde, sıcaklık artışının Doğu Anadolu Bölgesi'nde 1.74°C/50 yıl değerinde olduğu gözlemlenmiştir. En yüksek ortalama sıcaklık artışı sonbaharda Ege Bölgesi'ne (1.61°C), kış mevsiminde Doğu Anadolu Bölgesi'ne (2.37°C), ilkbaharda Doğu Anadolu Bölgesi'ne (1.84°C) ve yaz mevsiminde Marmara Bölgesi'ne (2.79°C) aittir. Ayrıca, yıllık sıcaklık trendleri çoğu istasyonda %99 güven aralığında artış şeklinde yaşanmıştır. %99 güven aralığında artan trendler, çoğu bölgede mevsimsel ve yıllık sıcaklık analizinden doğrulanmıştır.

Anahtar Kelimeler: İklim Değişikliği, Sıcaklık, Mann-Kendall Test, Trend Analizi, Türkiye

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1. INTRODUCTION

The socio-economic, cultural, urbanization and population changes in the world have accelerated in recent years. Especially after the Industrial Revolution, with the effects of technological developments, development levels of the countries increased in short time intervals. Changing living standards have also changed their impact on the environment in which people live. Climate change has been more recognized around the world as a result of these improvements. Consequently, studies on climate change which are carried out by both international organizations and researchers have gained momentum in recent years.

Climate change is defined, in the Intergovernmental Panel on Climate Change (IPCC), as continuous changes in climate characteristics over a long period of time (IPCC, 2014). The events of climate change since the 1950s have not been experienced for tens of thousands of years. As the atmosphere heats up, melting of glaciers has been observed during this process. Therefore, sea levels have started to increase. Warming in the ocean and land have been found out as 0.85 °C [0.65 - 1.06] °C by analyzing the temperature data from 1880 to 2012 in worldwide (IPCC, 2014). Climatic Research Unit have also recorded that the surface temperature of the earth has increased to approximately 0.17 °C every 10 years since 1970. The last five years have been determined to be the warmest years (CRU, 2020).

Investigations on climate change have been taken important steps in Turkey as well as worldwide. Several authors have reported significant research which have contributed majorly to field of climate change (Abbasnia and Toros, 2020; Akkoyunlu et al., 2019;Baltaci et al., 2018; Akkoyunlu et al., 2018; Toros et al., 2017; Kindap et al., 2012; Tayanç et al., 2009a; Tayanç and Toros, 1997;Tayanç et al., 1997;Karaca et., 1995). High variability in Central Anatolia, Eastern Anatolia and Southeastern Anatolia Region have been determined because of continental climate features. These three regions have a warming period in the 1950s. Then, unlike the warming period, a cooling period was experienced until 1976 in Central Anatolia Region. A cooling effect has been observed again from 1980 to 1993 in Central and Eastern Anatolia Region. Other outcomes have been found as a decrease in average temperature of Eastern and Southeastern Anatolia Region in the 2000s (Tayanç et al., 2009). According to results of other regions, there have been a less variation in average temperature of Mediterranean, Aegean, Marmara and Black Sea Region which are located coastal areas. Slight warming in Mediterranean Region has been declared except for a decrease (Tayanç et al., 2009).

Moreover, trend analysis is one of the most preferred methods in determining the course of climate change by many researchers around the world (Milentijević et al., 2020;Alhaji et al., 2018; Li et al., 2011; Radhakrishnan et al., 2017; Zeleňáková et al., 2015; Zaval et al., 2014; Saboohi et al., 2012). The non-parametric Mann-Kendall trend test has also been used by many authors who analyzed climatic variables, temperature and precipitation, to reveal recent climate change in Turkey. Demir et. al.,(2017) analyzed temperature and precipitation values of Bingöl province for 1975-2016 time period. Outcomes on yearly temperature basis reveal increasing changes. A few researchers (Saplıoğlu and Kilit, 2012) reported trends of temperature and precipitation data which belong to Afyon city from 1929 to 2011 time period. According to findings obtained, there have been increasing trends at 95% confidence interval in June and July. Avci and Esen (2019) found out climatic trends of Malatya province between 1975-2017 years by using Mann-Kendall test. Increase in average temperature has been observed for this time period. In addition, the minimum, average and maximum temperatures will continue to increase until 2040. Another research also demonstrates that results of climatic trends in Kilis for 1975-2016 years by performing non-parametric Mann-Kendall test. There have been detected increasing trends at 95% confidence interval in April, June and July(Ercan and Yüce, 2018).

In this research, we aimed to study to assess recent temperature changes and trends in each region of Turkey during the last half century. For this purpose, 174 meteorological stations were preferred to detect temperature variabilities and trends in the periods of 1969-2018. Linear

regression, 3-yr moving average and non-parametric Mann-Kendall trend test were used to analyze temperature values.

2. MATERIALS AND METHODS

2.1. Materials

Daily temperature data of 174 stations was taken from Turkish State Meteorological Service to evaluate temperature changes. Figure 1 demonstrates the spatial distribution of the meteorological stations. Temporal and spatial variability of temperature values were investigated by method of linear regression, 3-yr moving average and non-parametric Mann-Kendall test. Annual and seasonal average temperatures of each region; Aegean, Marmara, Black Sea, Mediterranean, Eastern Anatolia, Southeastern Anatolia and Central Anatolia Region were studied for the period of 1969-2018.

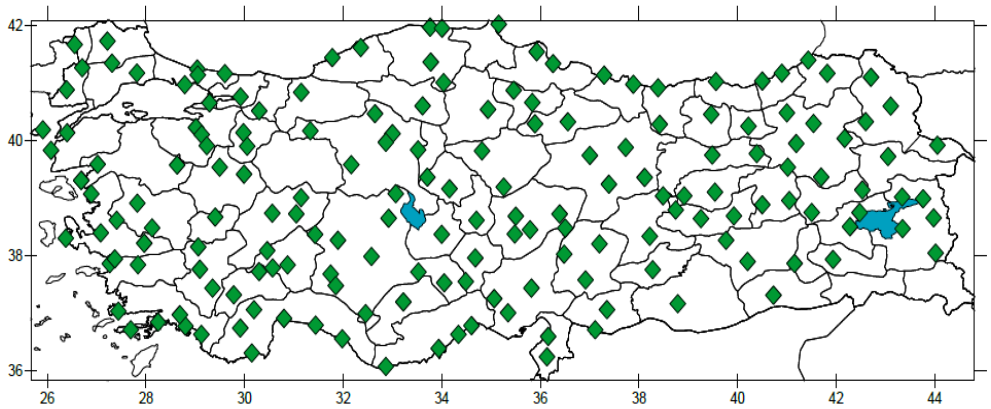


Figure 1:.
Spatial distribution of meteorological stations

2.2. Methods

Historically, the Mann-Kendall trend test was developed by Mann (Mann, 1945) and Kendall (Kendall, 1948) and then the widely used test statistic was derived (Brown et. al, 1992). This hypothesis test is based on ranks and is classified in non-parametric tests. The data is sorted by time and then each data point is consecutively evaluated as the reference data point. It is compared with all subsequent data points over time. Non-parametric tests are considered to be more appropriate than parametric tests in data that do not show normal distribution (Dash and Hunt, 2007). In a time series, y_i represents each value. The number of y_j elements before y_i is calculated to be $y_i > y_j$. Sum of P is formulated below.

$$P = \sum_i ni \tag{1}$$

t, the equation for the normalized Kendall rank coefficient is given below:

$$t = \frac{4P}{n(n-1)} - 1 \tag{2}$$

The distribution of the coefficient t is accepted close to the Gaussian's normal distribution with E (t) = 0.

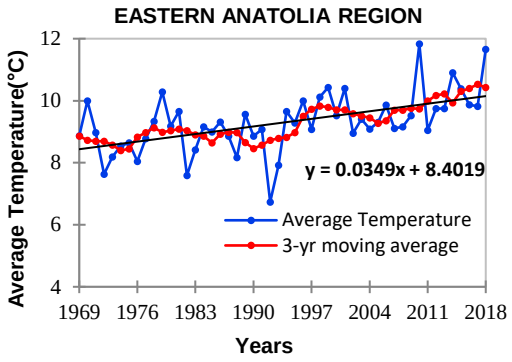
$$var(t) = (4n+10)/(9n)(n-1) \tag{3}$$

If the test statistic of the analysis is more than 1. 96, it indicates a positive trend. The test statistic that less than -1. 96 (Sneyers, 1990).

Mann-Kendall trend test was performed in XLStat which is an application of MS-Excel, in the scope of this work. Another method, moving average is a generally preferred method which demonstrates trends of a data set. Calculation of a moving average indicates creating a series of averages of different subsets of the full data set. It was also given results of linear regression in the graphs of each region.

3. RESULTS AND DISCUSSION

Figure 2 indicates yearly average temperature and 3-yr moving average signals of the regions belonging to Turkey. Yearly average temperature of Eastern Anatolia Region in the periods of 1969-2018 is observed, it has been detected an increase in average temperature in this region (Figure 2.a). Increasing temperature is stated as 0.035 °C in one year, roughly 0.35 °C in a decade and 1.74 °C in five decades. In this context, increase of 3.5 °C in temperature is expected after ten decades in Eastern Anatolia Region, as seen Figure 2.a. When yearly average temperature of Mediterranean Region is investigated in Figure 2.b, there is a presence of increase in average temperature in the same way. As a result of observations, increase in average temperature has appeared approximately 0.032 °C in one year, 0.32 °C in a decade and 1.59 °C in five decades. The temperature increase after ten decades is expected to be as 3.2 °C. As given in Figure 2.c, average temperature of Aegean Region during 1969-2018 period is examined, it is interpreted that the temperature has increased in this 50-year time period, as well. Whereas the increase per year is measured as roughly 0.034 °C, it is calculated as roughly 0.34 °C in a decade and 1.71 °C in five decades. The temperature rise after a century is calculated to be 3.4 °C. Yearly average temperature of Southeastern Anatolia Region demonstrates the presence of increase in temperature. Temperature increase is calculated as roughly 0.031°C per year, 0.31°C in a decade and 1.57 °C in five decades. The increase in this region is estimated to reach 3.14 °C within ten decades, as understood in Figure 2.d. Moreover, temperature changes in Central Anatolia Region are shown in Figure 2.e. The increase in per year is 0.034 °C, 0.34 °C/10 years and 1.72 °C/50 years. The rise after ten decades is predicted as 3.4 °C. As presented in Figure 2.f, temperature increase during the half century is obvious from examining analysis of Black Sea Region. Increase with a value of roughly 0.03 °C per year, 0.3 °C in a decade and 1.49 °C in five decades have been determined in this region. Expected increase is to be 3 °C after ten decades, seen Figure 2.g. Finally, Marmara Region has also an increase in yearly average temperature. Temperature change in Marmara Region increased to 0.034 °C per year 0.34 °C in a decade, and 1.71 °C in five decades. Estimation of increase after ten decades will be 3.4 °C in Marmara Region. In the light of this information, whereas the highest temperature increase is in the Eastern Anatolia Region, the region with the least temperature increase belongs to the Black Sea Region.



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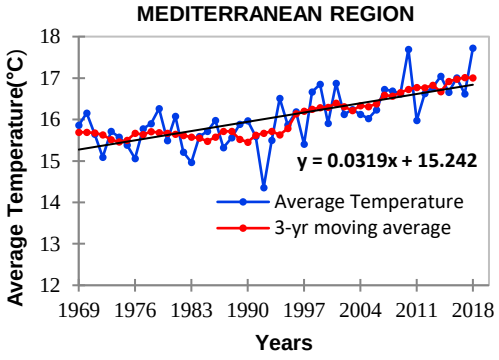

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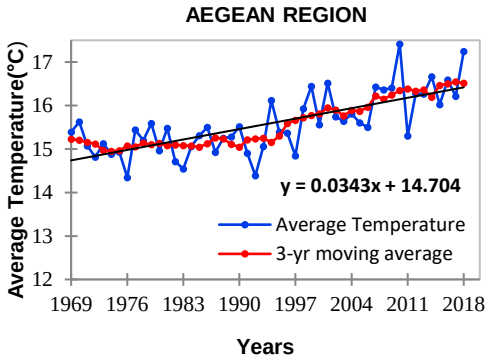

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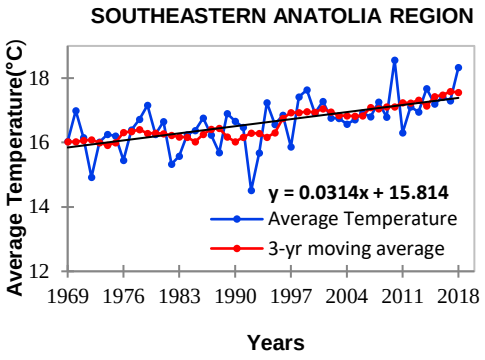

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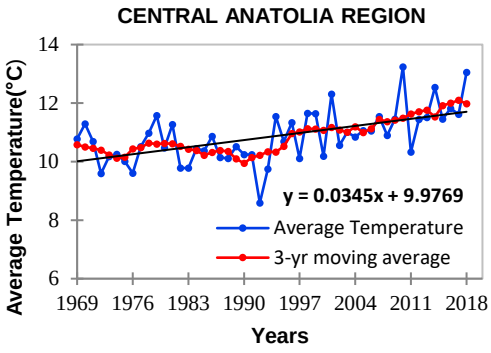

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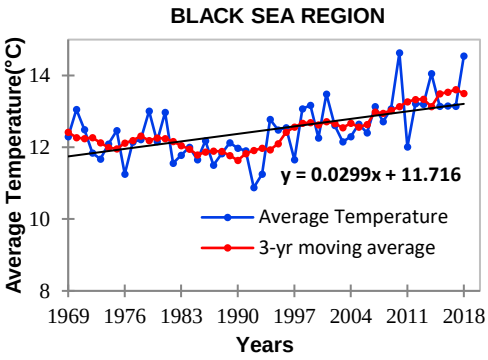

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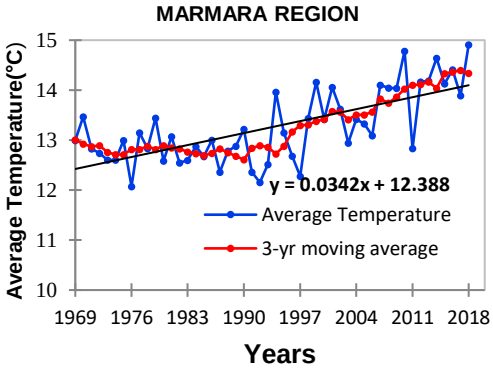

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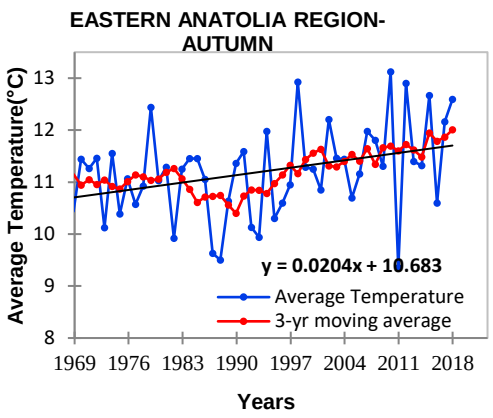
Figure 2:

Yearly average temperature and 3-yr moving averages of ***a.*** *Eastern Anatolia Region,* ***b.*** *Mediterranean Region,* ***c.*** *Aegean Region,* ***d.*** *Southeastern Anatolia Region,* ***e.*** *Central Anatolia Region,* ***f.*** *Black Sea Region,* ***g.*** *Marmara Region*

Visualization of average temperature and 3-yr moving average in autumn season for each region is clearly seen from Figure 3. Increase of Eastern Anatolia Region has been found out as 0.02 °C per year, 0.2 0.2 °C in a decade and 1.02 °C in five decades. According to Figure 3.a,

future prediction is foreseen to reach to 2.04 °C after ten decades. Another analysis results reveal as approximately 0.03 °C per year, approximately 0.3 °C for a decade and 1.35 °C for five decades in Mediterranean Region. Temperature rise is predicted to reach to 3°C after ten decades. There has been detected an increase of 0.03 °C/year, 0.3 °C/10 years and 1.615 °C/50 years in examination of Aegean Region. The temperature change will rise to 3°C after ten decades, as seen Figure 3.c. Southeastern Anatolia Region has also increase with an amount of 0.02 °C per year, 0.2 °C in a decade and 1.04 °C in five decades. Future estimation will be 2.08 °C within ten decades. The results of applying linear regression and 3-yr moving average belonging to Central Anatolia Region were given in Figure 3.e. It is interpreted from Figure 3.e. that temperature changes can be listed as follows 0.027 °C per year, 0.27 °C in a decade and 1.37 °C in five decades. There will be an increase of 2.74 °C after ten decades throughout autumn season. Outcomes from analysis of Black Sea Region indicate a rise with a value of 0.027 °C for a year, 0.27 °C for 10-year time period and 1.37 °C for 50-year time period, can be seen in Figure 3.f. Calculation for ten decades reveals as 2.74 °C in this region. Final analysis in autumn time was given in Figure 3.g. Marmara Region has also a rise of 0.03 °C/year, 0.3°C/10 years and 1.45 °C/50 years. Assessment about future rise is expected to 2.9 °C after ten decades in autumn time. Consequently, it is seen that the region with the highest temperature increase is Aegean Region. In addition, Eastern Anatolia Region has been identified as the region with the lowest temperature increase in autumn season.



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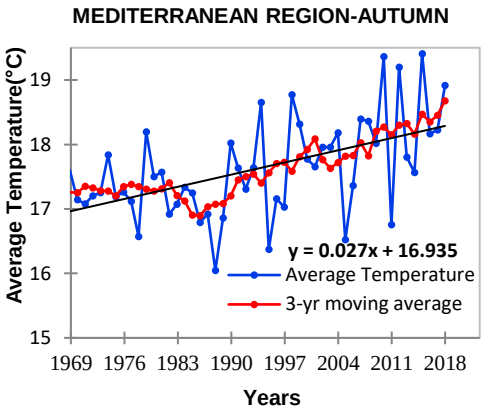

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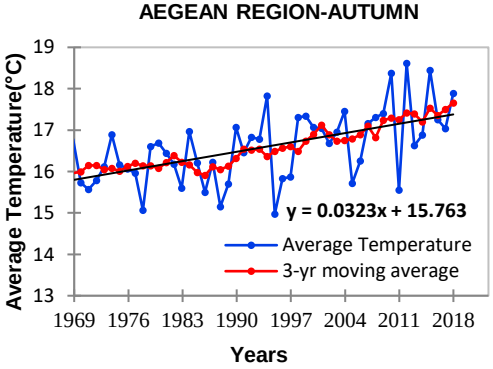

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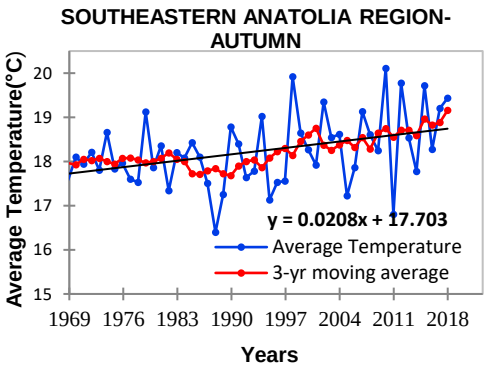

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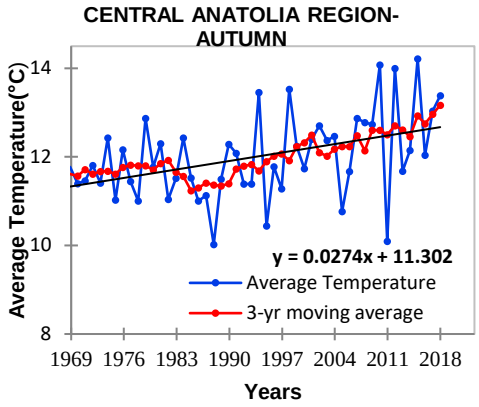

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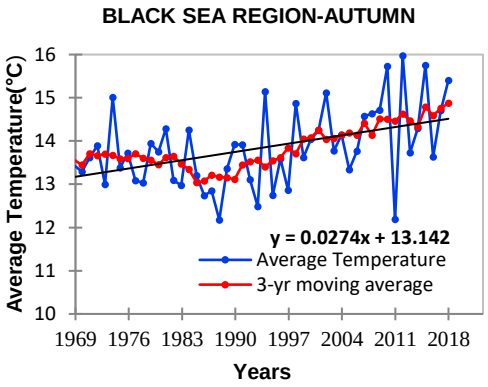

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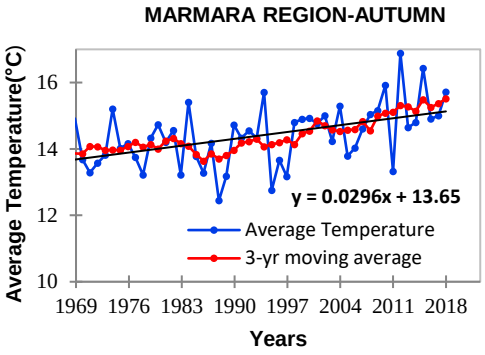

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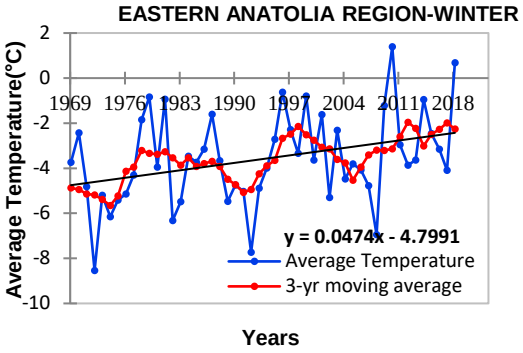
Figure 3:

Autumn average temperature and 3-yr moving averages of ***a.*** *Eastern Anatolia Region,* ***b.*** *Mediterranean Region,* ***c.*** *Aegean Region,* ***d.*** *Southeastern Anatolia Region,* ***e.*** *Central Anatolia Region,* ***f.*** *Black Sea Region,* ***g.*** *Marmara Region*

Winter temperature increase in Eastern Anatolia Region has been detected as 0.047 °C in a year, 0.47 °C in a decade and 2.37 °C in five decades, seen Figure 4.a. Future calculation is determined to reach 4.74 °C in ten decades. Temperature rise in Mediterranean Region reveal as 0.026 °C in a year, about 0.26 °C in ten years and 1.34 °C in fifty years. Future analysis demonstrates an increase with a value of 2.68 °C after ten decades, as understood from Figure 4.b. Another observation belonging to Aegean Region has also increase with an amount of about 0.019 °C per year, 0.19 °C in a decade and 0.94 °C in five decades as seen in Figure 4.c. According to future finding, temperature increase will be 1.88 °C after ten decades. Average temperature of Southeastern Anatolia Region in wintertime has been observed for long time periods, as well. Outcomes indicate an increase of 0.035°C in a year, 0.35 °C in ten years and 1.75 °C in fifty years. Evaluation of increase after ten decades is stated as 3.5 °C. Average temperature and 3-yr moving average of Central Anatolia Region is seen from Figure 4.e. While temperature changes is found out to increase of 0.031 °C in a year, 0.31 °C in ten years and 1.56 °C in five decades. If it is considered wintertime temperature of Black Sea Region, increase of approximately 0.023 °C is observed in a year, whereas it has been determined as 0.23°C in a decade and 1.13 °C in five decades, as seen Figure 4.f. In addition, it can be interpreted from Figure 4.g, 2.26 °C increase in temperature is expected after ten decades in the Black Sea Region. Final calculation indicates also an increase with an amount of 0.017 °C in a year, 0.17 °C in ten years and 0.83 °C in fifty

years in Marmara Region. In addition, it is estimated that the temperature increase will be 1.66 °C after ten decades. According to these results, the region with the highest temperature increase in winter season is determined as the Eastern Anatolia Region, the region with the lowest temperature is determined as Marmara Region.



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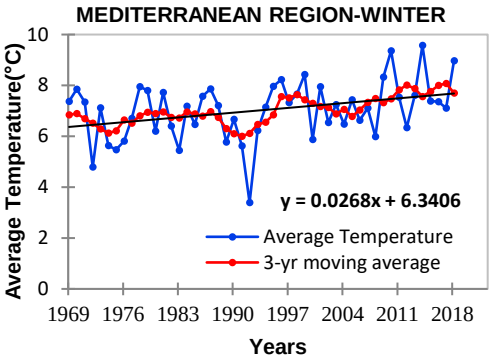

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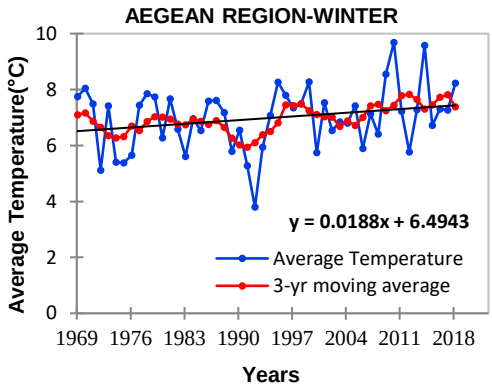

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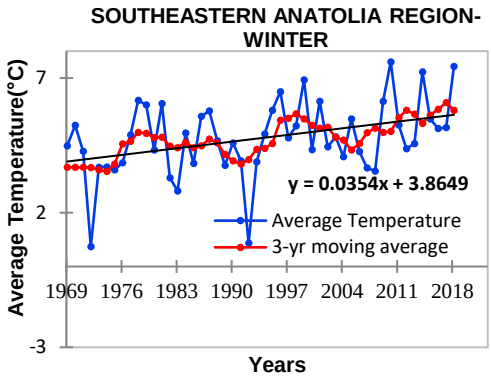

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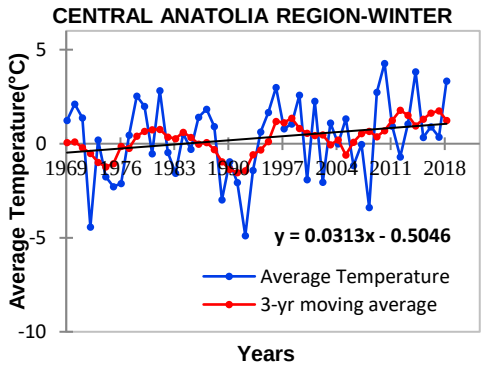

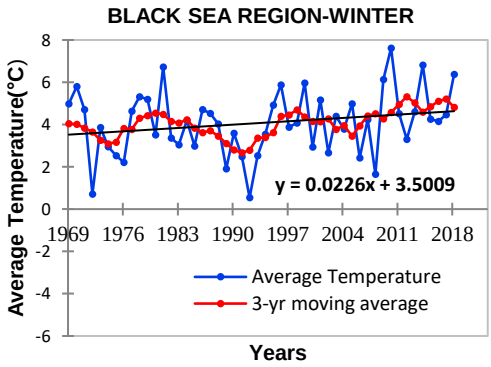

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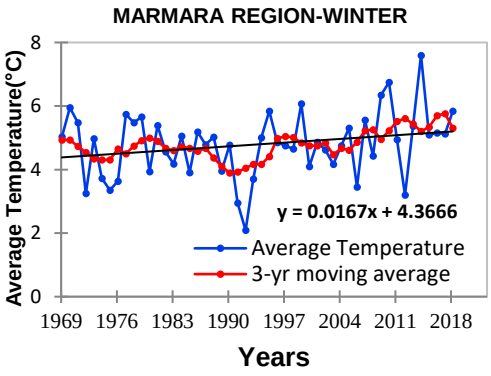

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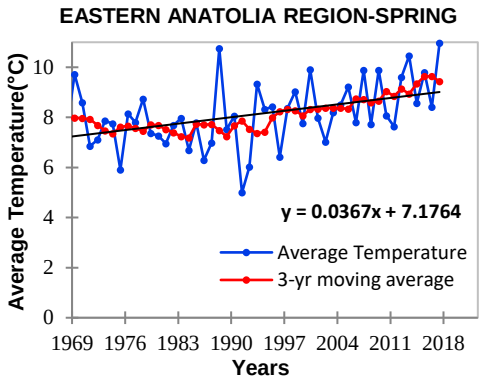
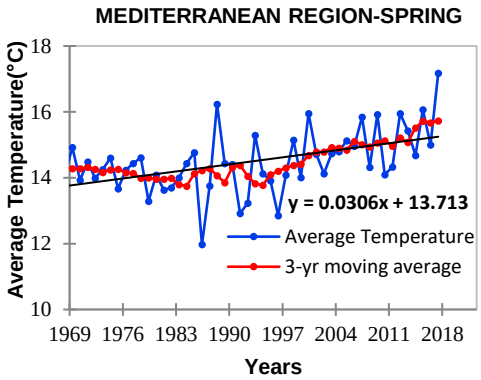
Figure 4:

Winter average temperature and 3-yr moving averages of ***a.*** *Eastern Anatolia Region,* ***b.*** *Mediterranean Region,* ***c.*** *Aegean Region,* ***d.*** *Southeastern Anatolia Region,* ***e.*** *Central Anatolia Region,* ***f.*** *Black Sea Region,* ***g.*** *Marmara Region*

Spring temperature rise in Eastern Anatolia Region has been stated as 0.037 °C/year, 0.37 °C/10 years and 1.84 °C/50 years, as illustrated in Figure 5.a. Future rise will reach to 3.68 °C in this region. It can be understood from Figure 5.b, temperature rise is determined as 0.031°C in per year, 0.31 °C in a decade and 1.53 °C in five decades. Temperature increase has appeared as 3.06 °C after ten decades. When temperature values of Aegean Region are examined, temperature increases have been revealed with an amount of 0.033 °C per year, 0.33 °C in a decade and 1.62 °C in five decades. The temperature rise has been detected as 3.24 °C in a century. Temperature of Southeastern Anatolia Region in spring season is presented in Figure 5.d. The temperature increases are seen as 0.029 °C per year, 0.29 °C in ten years, 1.45 °C in fifty years. The future temperature is found out as 2.88°C after ten decades. Assessments of Central Anatolia Region indicate an increase of 0.029 °C per year, 0.29 °C in ten years, 1.44 °C in five decades. The future value is forecast to be 2.88 °C within ten decades. The average temperature of Black Sea Region has also an increase of roughly 0.022 °C per year, 0.22 °C in a decade and 1.11 °C in five decades, clearly seen from Figure 5.f. Future rise is to be 2.22 °C after ten decades in this region. Moreover, temperature increase of springtime in Marmara Region has been examined as 0.035 °C per year, 0.35 °C in a decade and 1.73 °C in five decades. Future increase is evaluated as 3.46 °C in this region, as seen Figure 5.g. Deduction from these findings that highest temperature increase has occurred in Eastern Anatolia Region. Contrary to, Black Sea Region has lowest temperature increase in springtime.



a.



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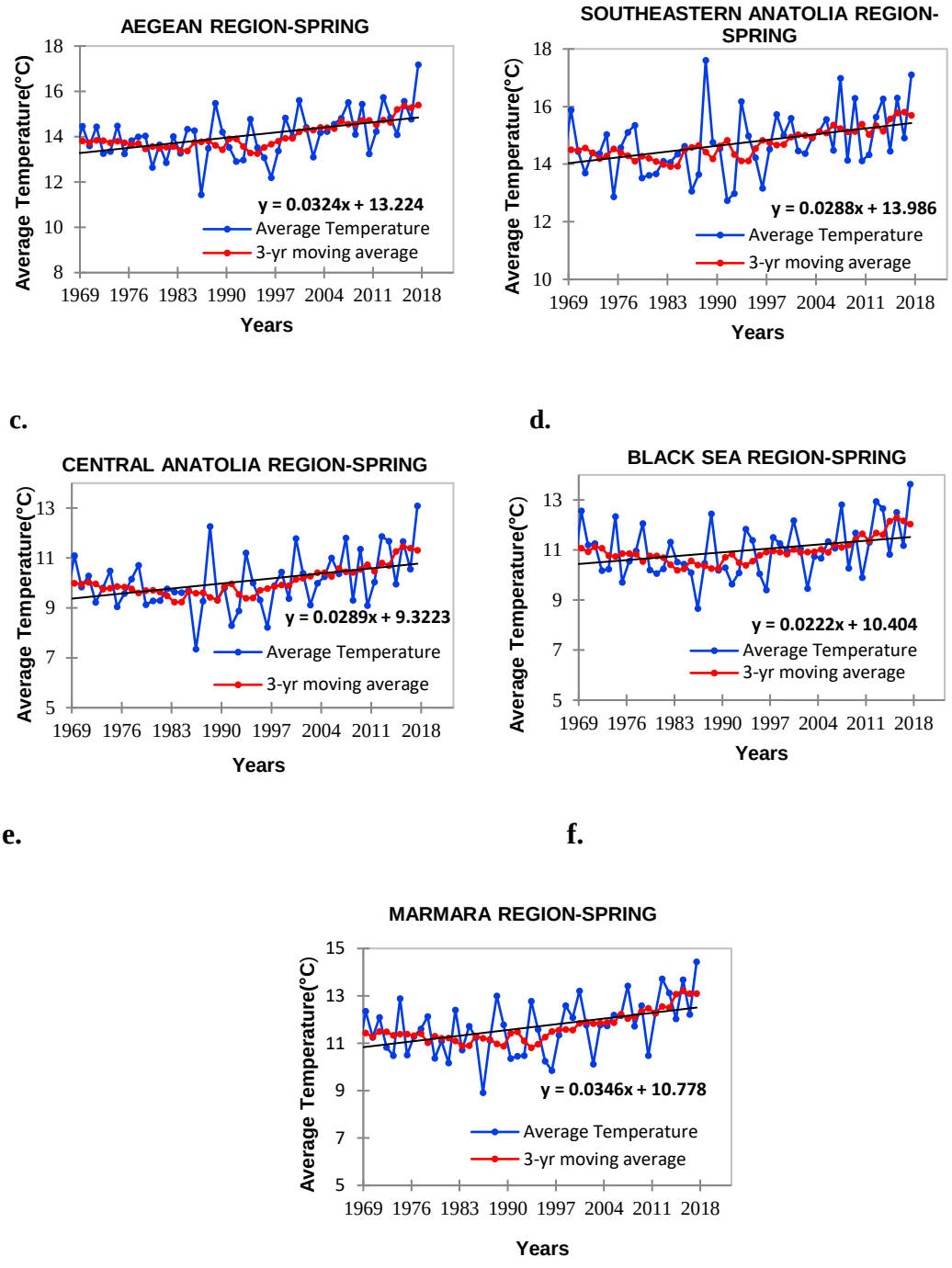


c. **d.**

e. **f.**

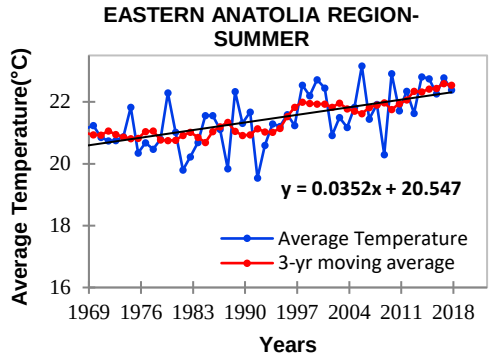
g.

Figure 5:

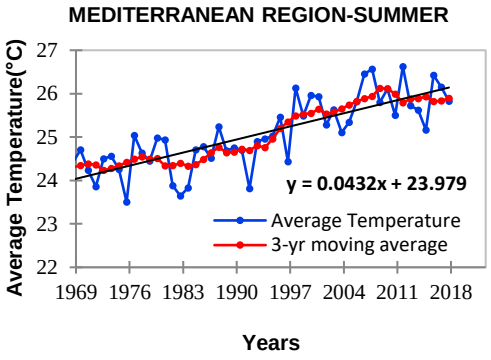
*Spring average temperature and 3-yr moving averages of **a.** Eastern Anatolia Region, **b.** Mediterranean Region, **c.** Aegean Region, **d.** Southeastern Anatolia Region, **e.** Central Anatolia Region, **f.** Black Sea Region, **g.** Marmara Region*

Temperature rise with a value of 0.035 °C per year, 0.35 °C in a decade and 1.76 °C in five decades have occurred in Eastern Anatolia Region, as illustrated in Figure 6.a. The rise in this

region is also expected to reach 3.52 °C in ten decades. As a result of examination of Mediterranean Region, outcomes have been found out as roughly 0.043 °C/year, 0.43 °C/10 years, 2.16 °C/50 years. The temperature increase will be as 4.32 °C after a century. Examination belonging to Aegean Region emphasizes temperature increase with an amount of 0.054 °C per year, 0.54 °C in a decade and 2.67 °C in five decades. According to future finding, temperature increase has appeared as 5.34 °C in this region, as charted in Figure 6.c. Temperatures increase of Southeastern Anatolia Region have been calculated as 0.041 °C per year, 0.41 °C in one decade and 2.035 °C in five decades. Future prediction becomes evident as 4.07°C within ten decades. Analysis of Central Anatolia Region proves that there is an increase with a value of 0.050 °C per year, 0.50 °C in a decade, 2.525 °C in five decades. Calculation of future has been stated as 5.05°C in summertime. Black Sea Region has also a rise of roughly 0.047 °C per year, roughly 0.47 °C in a decade and 2.35 °C in five decades. Future increase has been predicted as 4.7 °C in ten decades, seen from Figure 6.f. Finally, average temperature of Marmara Region has been determined as approximately 0.056 °C per year, approximately 0.56 °C for a decade and 2.79 °C for five decades. Rise after ten decades will be expected as 5.58 °C in this region. Therefore, while highest temperature increase in summertime has been observed in Marmara Region, the lowest temperature increase reveals in Eastern Anatolia Region.



a.



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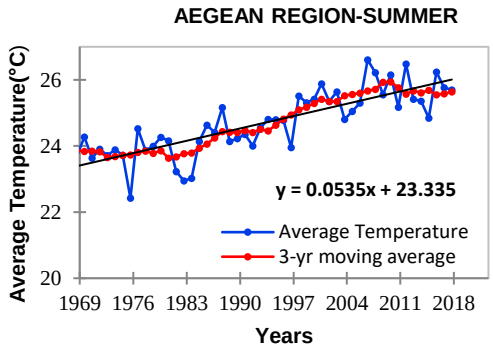

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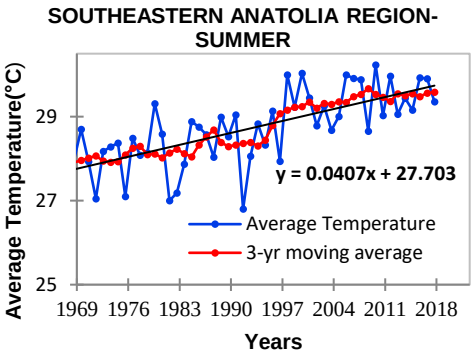

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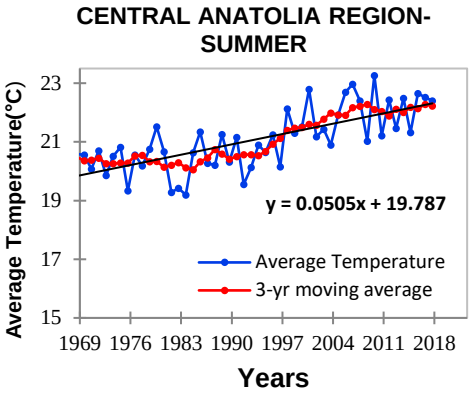
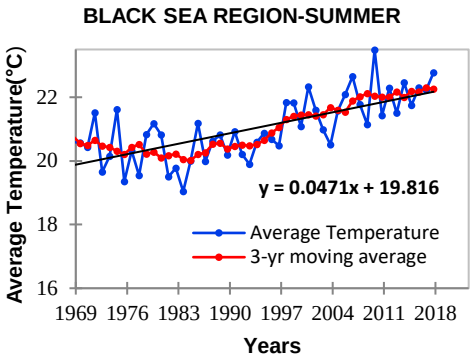


e.



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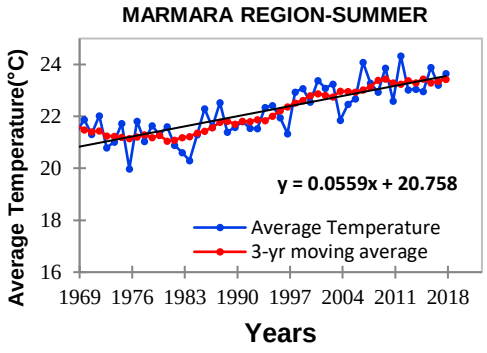

g.

Figure 6:

Summer average temperature and 3-yr moving averages of ***a.*** *Eastern Anatolia Region,* ***b.*** *Mediterranean Region,* ***c.*** *Aegean Region,* ***d.*** *Southeastern Anatolia Region,* ***e.*** *Central Anatolia Region,* ***f.*** *Black Sea Region,* ***g.*** *Marmara Region*

Spatial and temporal trend analysis of stations were presented to be understood temperature trends in Figure 7. Most stations have strong warming trends at 99% confidence interval as well as others have increasing trends at 95% confidence interval. Consequently, it is able to say that most of stations have statistically increasing trends around Turkey.

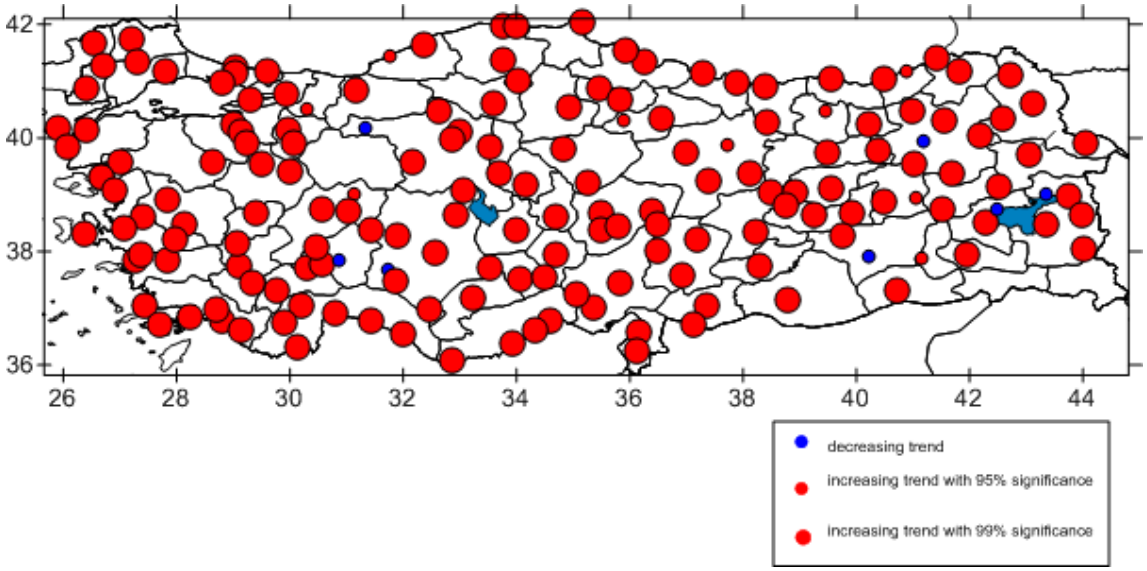

Figure 7:
Distribution of the Mann-Kendall test statistics over Turkey

The trend analysis of yearly temperatures in the each Turkey's region between 1969 and 2018 periods is clearly seen in the Table 1. The results obtained demonstrate that there have been a presence of statistically significant temperature increases, at 99% confidence interval, in all region. Another outcomes by (Can and Atimtay, 2002) on mean air temperature over Turkey have been reported that there have been statistically decreasing trends in 75% of stations in Black Sea Region from 1950 to 1994. Marmara Region has statistically decreasing trends in 36% of stations except for most stations with to not observe any trends. Significant decreasing trends have been noted from 40% of stations in Eastern Anatolia Region. It has been also presented significant negative trends in %28 of stations belonging to Mediterranean Region. Contrary to, significant positive trends have been observed from 14% of stations in this region during 1950-1994 time periods.

Table 1. Results of annual trend analysis

Regions	**Kendall's tau**	**S**	**Z**
Eastern Anatolia Region	0.399	489	4.0821
Mediterranean Region	0.508	623	5.2029
Aegean Region	0.502	615	5.136
Southeastern Anatolia Region	0.472	579	4.8349
Central Anatolia Region	0.399	489	4.0821
Black Sea Region	0.389	477	3.9817
Marmara Region	0.443	543	4.5338

Analysis of autumn season temperature trends during 1969-2018 years was presented in Table 2. According to the findings, it was noted that there have been increasing trends at 95% confidence

interval only in the Eastern and Southeastern Anatolia Regions, while the temperature trends at 99% confidence interval have been detected in other regions.

Table 2. Results of trend analysis in autumn season

Regions-Autumn	Kendall's tau	S	Z
Eastern Anatolia Region	0.221	271	2.2585
Mediterranean Region	0.343	421	3.5132
Aegean Region	0.389	477	3.9817
Southeastern Anatolia Region	0.227	279	2.3254
Central Anatolia Region	0.283	347	2.8942
Black Sea Region	0.289	355	2.9612
Marmara Region	0.340	417	3.4798

Temperature trend analysis for each region in winter season can be found in the Table 3. According to this Table 3, whereas there is no trend observed in Aegean, Central Anatolia, Marmara, Black Sea Region, in wintertime, it has been stated increasing trends at 95% confidence interval in the Eastern Anatolia, Mediterranean and Southeastern Anatolia Region. Demir et.al, (2008) found that average temperatures of wintertime generally demonstrate weak negative trends. Whereas significant negative trends have been reported in only Sinop, Zonguldak and İnebolu, significant positive trends have been observed from Alanya, Mersin (Demir et. al., 2008).

Table 3. Results of trend analysis in winter season

Regions- Winter	Kendall's tau	S	Z
Eastern Anatolia Region	0.222	273	2.2752
Mediterranean Region	0.206	253	2.1079
Aegean Region	0.100	123	1.0205
Southeastern Anatolia Region	0.239	293	2.4425
Central Anatolia Region	0.128	157	1.3049
Black Sea Region	0.167	143	1.1878
Marmara Region	0.126	155	1.2882

The Table 4 indicates trend analysis results for spring season. Increasing trends at 95% confidence interval have been determined in Central Anatolia and Black Sea Region. On the other hand, there is a presence of increasing trend at 99% confidence interval in other regions. It is stated that significant positive trends in springtime exist in Southeastern Anatolia, Mediterranean and Marmara Region (Demir et al., 2008).

Table 4. Results of trend analysis in spring season

Regions- Spring	Kendall's tau	S	Z
Eastern Anatolia Region	0.297	365	3.0448
Mediterranean Region	0.327	401	3.3459
Aegean Region	0.302	371	3.095
Southeastern Anatolia Region	0.258	317	2.6433
Central Anatolia Region	0.242	297	2.476
Black Sea Region	0.188	231	1.9239
Marmara Region	0.286	351	2.9277

Results of trend analysis in summer season are able to be seen in Table 5. It is noteworthy that strong warming has been observed during 1969-2018 time periods. Each region has an increasing trend at 99 % confidence interval. Significant increasing trends have been found out from average temperature of summertime except for a few stations from 1952 to 2006 (Demir et. al., 2008).

Table 5. Results of trend analysis in summer season

Regions- Summer	Kendall's tau	S	Z
Eastern Anatolia Region	0.420	515	4.2995
Mediterranean Region	0.593	727	6.0729
Aegean Region	0.640	785	6.558
Southeastern Anatolia Region	0.500	613	5.1193
Central Anatolia Region	0.506	621	5.1862
Black Sea Region	0.497	609	5.0858
Marmara Region	0.589	719	6.006

4. CONCLUSIONS

Special focus in this study is to assess climate change effects on Turkey for 50-year period. For this purpose, 174 meteorological stations were selected to detect temperature variabilities and trends from 1969 to 2018. Each region has been examined by linear regression, 3-yr moving average and non-parametric Mann-Kendall trend test.

As a result of linear regression, temperature increases have been experienced throughout this 50-year period in each region on seasonal and annual basis. Yearly outcomes indicate that highest temperature increase has been noted to occur in Eastern Anatolia Region. In addition, seasonal findings have been stated that highest temperature increase autumn, winter, spring and summer respectively follow as Aegean, Eastern Anatolia, Eastern Anatolia and Marmara Region. On the

other hand, with the applying Mann-Kendall test, yearly temperature trend belonging to each region reveals increasing trends at 99% confidence interval. Autumn temperatures have increasing trends at 95% confidence interval only in Eastern and Southeastern Anatolia Region. Presence of positive trends at %99 confidence interval has been found out in other regions. It has been reported that increasing trends at %95 confidence interval have been stated in Eastern, Southeastern, Mediterranean Region from wintertime temperature. Spring temperatures indicate both increasing trends at 99% and 95% confidence interval. Whereas Central Anatolia and Black Sea Region have positive trends at 95% confidence interval, positive trends at 99% confidence interval have been observed in other regions. Summer temperatures also have statistically positive trends at 99% confidence interval in all regions.

This work manifests important outcomes related to global temperature increase effects on Turkey. By determining the annual and seasonal average temperature of each region, the maximum and minimum increase in average temperatures were revealed. Thus, the regions which are most affected by climate change and where the changes are the most and the least have been found. The temperature increases which are experienced in the Mediterranean Basin can be seen from the results that it has been occurred in Turkey during this 50-year period. Statistically significant increases were observed in the seasonal and annual average temperatures of the regions. It is also foreseen that temperature increases will continue to increase in the future. For this reason, studies on climate change should be increased and strategies for adaptation to climate change should be well defined and implemented.

CONFLICT OF INTEREST

The authors acknowledge that there is no known conflict of interest or common interest with any institution / organization or person.

AUTHOR CONTRIBUTION

Tuğba Çelebioğlu and Mete Tayanç contributed to the determination of the conceptual and design processes of the study, its management, data collection, data analysis, interpretation and drafting of the article. In addition, Halil Nurullah Oruç took part in the data analysis part of the article.

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