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Trend analysis of temperature and precipitation data of 9 stations located in Mediterranean region

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ABSTRACT

Trend is defined as a statistically significant decrease or increase in the measured values of a parameter over the time series. Since hydrological values are of randomly changing character over time, special methods should be used to investigate the tendency to decrease or increase. In this study, Linear Trend and Modified Mann-Kendall trend analyzes were examined using the annual average temperature data (℃) and the annual total precipitation data (mm) between the years 1960-2020 of 9 stations in the Mediterranean Region. Study was performed in 95% confidence interval. According to the results of the study carried out there are increasing trends in temperature data in 8 of the 9 stations and no trend in precipitation data.

1. INTRODUCTION

Climate changes affect the entire ecosystem over time, causing significant changes in hydrometeorological parameters. For this reason, performing analysis of these parameters is of vital importance in detecting extreme situations that may occur over time. İçel (2009), in her study examined the temperature and precipitation values and extreme cases in the eastern Mediterranean coast and determined an increasing trend in 11 stations and stated that this increase is more apparent after the year 1992. Bahadır (2011), studied the temperature and precipitation trend changes in the Mediterranean Region with the Growth Curve and ARIMA model and determined all stations revealed an increase in temperature and a decrease in precipitation. Gönençgil and İçel (2014), in their study, they carried out investigations using ANOVA method for precipitation data of 11 stations located on the Eastern Mediterranean coast between 1975-2006 and as a result of these investigations, they found a decrease in the annual total precipitation and the annual total number of rainy days. Çelik (2019), in his study, conducted drought analyzes (SPI) for 15 stations located on the Mediterranean coast between 1967 and 2016 and found extreme climate conditions were frequently experienced. Yücel et al. (2019), in their study, they determined statistically significant increasing trends in temperature data and statistically decreasing trends in precipitation data. In this study, Linear Trend and Modified Mann-Kendall trend analysis methods were used to determine statically significant trends and analysis was performed in 95% confidence interval.

2. METHOD

Mediterranean Region covers the 3 major basins, namely he Eastern Mediterranean basin, the Antalya basin and the Western Mediterranean basin. The region is of great importance in agriculture and tourism. The region, which has a Mediterranean climate, receives hot and dry summer and warm and abundant rainfall in winter seasons.

Detailed information of stations was given in Table 1. and station location were shown on map in Fig. 1.

Figure 1. Station locations

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Table 1. Statistical information about temperature and precipitation data

No	Data	Period	Std. Dev.	Skew.	Kurt.
17238 Burdur	Temp.	1960-2020	0.73	0.25	-0.32
	Pre.	1960-2020	85.30	0.02	-0.59
17240 Isparta	Temp.	1960-2020	0.81	0.14	0.04
	Pre.	1960-2020	142.06	0.42	0.26
17255 Kahramanmaraş	Temp.	1960-2020	0.91	-0.17	-0.21
	Pre.	1960-2016	171.22	0.69	0.25
17292 Muğla	Temp.	1960-2020	0.58	0.02	-0.47
	Pre.	1960-2020	280.05	0.18	0.00
17302 Antalya	Temp.	2001-2020	0.55	0.72	0.39
	Pre.	2006-2020	451.59	-0.30	-1.49
17340 Mersin	Temp.	1960-2020	1.03	0.20	-0.93
	Pre.	1960-2020	182.46	0.53	0.03
17351 Adana	Temp.	1960-2020	0.57	0.28	0.54
	Pre.	1960-2020	202.51	0.72	0.38
17355 Osmaniye	Temp.	1986-2020	0.64	-0.23	0.01
	Pre.	1986-2020	168.43	0.35	0.18
17372 Antakya	Temp.	1960-2020	0.64	-0.20	0.03
	Pre.	1960-2020	185.29	0.28	-0.22

When Table 1. containing statistical information on temperature and precipitation data is examined, it is seen that the temperature data of the stations are distributed symmetrically except for 1 (17302 /Antalya) station. When the same examination is applied to the kurtosis coefficients, it is seen that all 9 stations are flatter (Platykurtic) than the normal distribution curve. For precipitation data, it is seen that the stations are distributed symmetrically except for 3 (17255/Kahramanmaraş, 17340/Mersin, 17351/Adana) stations. When the same examination is applied to the kurtosis coefficients, it is seen that all 9 stations are flatter (Platykurtic) than the normal distribution curve.

2.1. Linear Trend Test

Linear Trend test is a parametric test that assumes the data is normally distributed and used to determine the presence or absence of a trend in a time series (Karabulut and Cosun 2009). This method's application is mainly based on graph and the line (Eq. 1) fitted to this graph to determine the trend curve (Yağbasan et al. 2020).

$$y_i = ax_i + b \quad (1)$$

In Eq. 1. "a" represents slope and "b" represents the intersection point with the y axis (Demir 2018). "a" and "b" values are calculated using Eq. 2. and 3.

$$a = \frac{\sum_{i=1}^{N} x_i y_i - N\bar{x}\bar{y}}{\sum_{i=1}^{N} x_i^2 - N\bar{x}^{-2}} \quad (2)$$

$$b = \bar{y} - a\bar{x} \quad (3)$$

In Eq. 2. and 3. variables "N" represents the number of data in the series, "$\bar{x}$" represents the average of "x" variables, "$\bar{y}$" represents the average of "y" variables, "x_i" represents the "x" value in the "i-th" row, "y_i" represents the "y" value in the "i-th" row.

Trend existence is decided by applying "t" distribution and "t" test (Eq. 4.).

$$f(t) = \frac{\Gamma(\frac{v+1}{2})}{\sqrt{v\pi}\Gamma(\frac{v}{2})}(1+\frac{t^2}{v})^{-\frac{v+1}{2}} \quad (4)$$

The calculated "t" value is compared with the "$t_{critical}$" value corresponding to the 95% significance level (Demir 2018).

2.2. Modified Mann-Kendall Test

In the original Mann-Kendall test, although the procedure is assumed to be independent, a correlation is observed in most of the hydrological events and the presence of positive autocorrelation increases the possibility of detecting a significant trend (Yağbasan et al. 2020). In order to eliminate this situation variance value is calculated with the help of Eq. 5 and 6. (Hamed and Rao 1998).

$$\frac{n}{n_s^*} = 1 + \frac{2}{n(n-1)(n-2)}\sum_{i=1}^{n-1}(n-i)(n-i-2)\rho_s(i) \quad (5)$$

$$V(S) = Var(S)\frac{n}{n_s^*} = \frac{n(n-1)(2n+5)}{18}\frac{n}{n_s^*} \quad (6)$$

And the rest of the test is carried out similiarly to the original Mann-Kendall test. After application calculated "Z" value compared with the "$Z_{critical}$" value to check statistically significant trend presence (Yılmaz et al. 2020).

3. RESULTS

In this study, Linear Trend and Modified Mann-Kendall trend analyzes were examined using the annual average temperature data (°C) and the annual total precipitation data (mm) between the years 1960-2020 of 9 stations in the Mediterranean Region. The obtained results were mapped with the help of ArcGIS software and visualized. The main purpose of this application is to concretize the trend results obtained and to determine their distribution over the region. Results from trend tests for temperature data are shown in Table 2.

Table 2. Trend test results for temperature data

No	Test	Critical Value	Result	Trend
17238 Burdur	LT	±1.67	3.77	Increasing
	MMK	±1.96	3.21	Increasing
17240 Isparta	LT	±1.67	3.23	Increasing
	MMK	±1.96	2.41	Increasing
17255 Kahramanmaraş	LT	±1.67	7.87	Increasing
	MMK	±1.96	6.11	Increasing
17292 Muğla	LT	±1.67	4.20	Increasing
	MMK	±1.96	3.06	Increasing
17302 Antalya	LT	-	-	-
	MMK	-	-	-
17340 Mersin	LT	±1.67	14.60	Increasing
	MMK	±1.96	8.00	Increasing
17351 Adana	LT	±1.67	3.92	Increasing
	MMK	±1.96	3.70	Increasing
17355 Osmaniye	LT	±1.69	2.97	Increasing
	MMK	±1.96	2.71	Increasing
17372 Antakya	LT	±1.67	3.55	Increasing
	MMK	±1.96	3.43	Increasing

-: Not enough data for trend analysis.
LT: Linear Trend Test
MMK: Modified Mann-Kendall Test

When the Linear Trend test results (Table 2.) for temperature data were examined, it was determined that increasing trends were found in 8 stations and the results obtained were found to be significant at 95% of the confidence interval. And the results of the Modified Mann-Kendall trend test (Table 2.) were examined, it was determined that increasing trends were found in 8 stations and the results obtained were found to be significant at 95% of the confidence interval. The results of the examination of both test shows increasing trends in 8 stations and there are extreme cases of increasing trends in 2 stations (17255/Kahramanmaraş, 17340/Mersin). Maps of Linear Trend and Modified Mann-Kendall Tests are shown in figures 2 and 3.

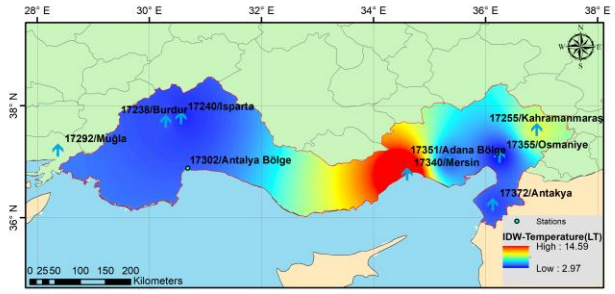

Figure 2. Map of the Linear Trend test results for temperature data

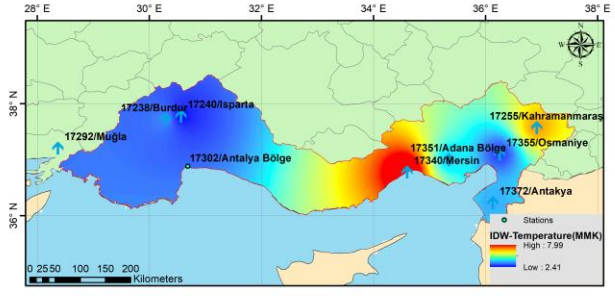

Figure 3. Map of the Modified Mann-Kendall trend test results for temperature data

Results from trend tests for precipitation data are shown in Table 3.

Table 3. Trend test results for precipitation data

No	Test	Critical Value	Result	Trend
17238 Burdur	LT	±1.67	-0.04	No trend
	MMK	±1.96	0.13	No trend
17240 Isparta	LT	±1.67	-1.50	No trend
	MMK	±1.96	-0.78	No trend
17255 Kahramanmaraş	LT	±1.67	0.52	No trend
	MMK	±1.96	0.46	No trend
17292 Muğla	LT	±1.67	-1.13	No trend
	MMK	±1.96	-0.87	No trend
17302 Antalya	LT	-	-	-
	MMK	-	-	-
17340 Mersin	LT	±1.67	0.71	No trend
	MMK	±1.96	0.67	No trend
17351 Adana	LT	±1.67	-0.31	No trend
	MMK	±1.96	-0.21	No trend
17355 Osmaniye	LT	±1.69	-0.68	No trend
	MMK	±1.96	0.03	No trend
17372 Antakya	LT	±1.67	-0.76	No trend
	MMK	±1.96	-0.68	No trend

-: Not enough data for trend analysis.
LT: Linear Trend Test
MMK: Modified Mann-Kendall Test

When the Trend test results (Table 3.) for precipitation data were examined, it was found that there was no significant trend in 95% of the confidence interval at any of the stations. Since there is no statistically significant trend in any of the trend test results for the precipitation data no map has created.

As for the test results for individual stations, only 17340/Mersin station will be examined as an example.

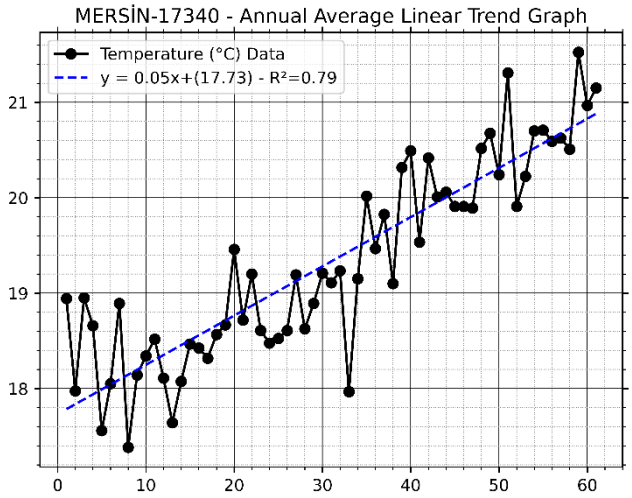

Figure 4. Linear Trend test graph for temperature data

As it is shown in Fig. 4 when the annual average temperature graph is examined a clear increase in temperature data over the years and statistically significant extreme case of increasing trend is observed for both tests (Table 2).

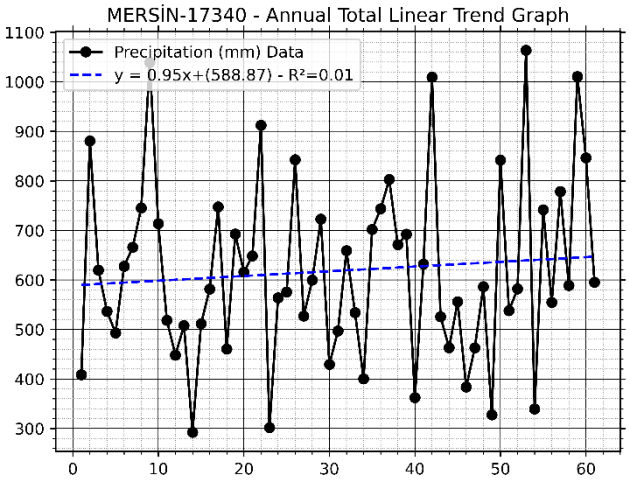

Figure 5. Linear Trend test graph for precipitation data

And an increasing trend can be observed for precipitation data. But this observation is not statistically significant for both tests (Table 3).

4. DISCUSSION

While temperature data generally gives high R^2 results, the R^2 values obtained from precipitation data is much lower. This means the linear projection of linear trend test does not fit well to the high fluctuations of precipitation data. But trend results obtained from tests are quite compatible for both tests. Increasing trends in temperature data expected to increase more in the near future (Bahadır 2011). These increasing trends in temperature data indicates an increase of demand in limited water resources (Yücel et al. 2019) and the relationship between temperature and humidity might affect the number of storms that will occur in the future (İçel 2009). For temperature data the stations that shows trend presence are in accordance with other studies (Yücel et al. 2019).

5. CONCLUSION

When results from both tests examined for temperature data, both tests show an increasing trend in 8 stations and 2 (17255/Kahramanmaraş, 17340/Mersin) of these stations has an extreme case of increasing trends. When the same examination was applied to the precipitation results no significant trend was detected in any of the stations for both tests.

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