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TREND ANALYSIS IN TEMPERATURE, PRECIPITATION AND HUMIDITY: THE CASE OF MEDITERRANEAN REGION

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Abstract

Temperature and precipitation values are important parameters of climate change. Therefore, studies on meteorological data are important and such studies are increasing. The Mediterranean region, where agriculture has been intensified as a study area, has been selected. Long-term temperature, precipitation and humidity values of the provinces in the study area were used as material. The measurement range of meteorological data covers the period between 1950 and 2018. Linear regression analysis (LRA) and Spearman trend test (STT) were applied to determine climatic changes in these values. According to the results of linear regression analysis and Spearman trend test, it is determined that the most changes in long-term daily temperatures are in Isparta, Mersin, Burdur, Adana, Antalya, Kahramanmaras and Osmaniye provinces. The provinces with relative humidity changes were determined as Isparta, Burdur, Mersin, Adana and Antalya. As a result, these and similar studies have shown that it can play an important role in the planning of agricultural crop cultivation areas.

Key words: *Mediterranean, precipitation, temperature, trend analysis.*

INTRODUCTION

Water and energy are critical parameters for agricultural activities. The regular application of water related activities in agriculture can be possible only by way of sufficient rainfall (Ülke & Özkoca, 2018).

The demand for water in our day is rapidly increasing with increasing population and accordingly the efforts to increase agricultural products and industrialization (Bahadır, 2011; Saplıoğlu & Çoban, 2013).

The changes and differences that take place in the atmosphere brought about changes in temperature and rainfall which make up the main elements of climate.

While the variations in climate are reflected differently in different regions of the world, different scientific communities are carrying out studies on this issue (Bahadır, 2011).

The changes in climate may emerge as significant changes in average temperatures in different regions of the world but they also include changes in rainfall. It is stated that the increases and decreases in the amount of rainfall are proofs of climate change. Rainfall is indicated to be a factor of climate system that changes the most subject to time and location (Karabulut et al., 2008).

Changes in climate have an impact on many sectors and hence they also affect the agriculture and food sectors. Dependence on nature is inevitable for agricultural activities no matter how developed technology becomes since they are carried out in and subject to nature (Bayraç & Doğan, 2016). Rainfall and temperature are especially indicated as climate parameters with an influence on agriculture (Demir et al., 2017). Since agriculture is an economic activity, changes in production due to climate change are important for the country as well as for international commerce. Agriculture is affected by the climate but is also considered as a field of activity that causes climate change. Agricultural activities such as irrigation, soil tillage, fertilization, use of pesticides and misuse of agricultural lands, energy consumption, animal-based production all increase the release of greenhouse gases to the atmosphere. Therefore, it is stated that the greenhouse gases released as a result of such activities result in global warming and climate changes (Başoğlu, 2014; Bayraç & Doğan, 2016).

It is estimated that more intensive and longer draughts will take place in our country with the increase of global warming. Hence, both water resources and agricultural activities subject to rainfall may be affected adversely (Ülke & Özkoca, 2018). Studies carried out until today on climate factors report that temperatures have increased, especially in recent years while rainfall is decreasing (Demir et al., 2017). Many researchers carry out trend analyses especially on rainfall and temperature and emphasize issues of global warming and climate change (Türkeş et al., 2002; Karabulut et al., 2008; Karabulut,2012; Bahadır, 2011; Demir et al., 2017; Yüce & Ercan, 2017; Ülke & Özkoca, 2018).

The purpose of this study was to evaluate using Linear Regression Analysis and Spearman Trend Test the long-term temperature, rainfall and humidity values recorded at meteorological stations in different cities in the Mediterranean Region for determining the changes in these parameters.

MATERIALS AND METHODS

In the study, the Mediterranean Region, where agricultural activities especially greenhouses production are carried out intensively, is determined as a research area. There is a total of 8 provinces in the region and the data obtained from the General Directorate of State Meteorological Affairs of these provinces were used. These data; long term daily maximum (T_{MAX}), average (T_{AVE}), minimum (T_{MIN}) temperature values, daily maximum (P_{MAX}, mm), average (P_{AVE}, mm), annual total (P_T, mm) precipitation values and maximum (RH_{MAX}, %), average (RH_{AVE}, %), minimum (RH_{MIN}, %) relative humidity values were used as material. Some features of the meteorological stations of the provinces in the Mediterranean region are given in Table 1.

Table 1. Some features of meteorological stations

Meteorological stations	Period duration (years) (n)	Height (H, m)	Latitude-North (E, °)	Longitude-East (B, °)
Adana	1950-2018 (69)	23	37°0041'	35°3443'
Antakya (Hatay)	1950-2018 (69)	104	36°2048'	36°1513'
Antalya	1950-2018 (69)	64	36°9063'	30°7990'
Burdur	1950-2018 (69)	957	37°7220'	30°2940'
Isparta	1950-2018 (69)	997	37°7848'	30°5679'
Kahramanmaraş	1959-2018 (60)	572	37°5760'	36°9150'
Mersin	1950-2018 (69)	7	36°7808'	34°6031'
Osmaniye	1986-2018 (33)	94	37°1021'	36°2539'

Researchers have developed various parametric and non-parametric methods in order to determine whether the trend changes occurring during the observation period (temperature, precipitation, etc.) are in the direction of increasing or decreasing. In this study, parametric LRA and nonparametric STT which is the most widely used trend method are preferred.

Linear Regression Analysis (LRA). It is called as the method that presents the causal relationship between two variables as dependent variables and independent variables with a linear model (Helsel and Hirsch, 1993; Hamdi et al., 2009; Shammugasundram, 2012). The following is expressed by simple equality:

$$Y = a + bX \quad (1)$$

Where: Y is the dependent variable, X is the independent variable, whereas a and b are equation regression coefficients (Haan, 1977; Sneyers, 1990; Kundzewicz and Rodson, 2000; Xu, 2002; Önöz & Bayazıt, 2003).

Spearman Trend Test (STT). It is one of the nonparametric trend tests. It is a quick and simple test used to determine whether there is an important trend between the values of the observations. Calculated in the following equations (Sneyers, 1990; Helsel & Hirsch, 1993):

$$R_{sp} = 1 - \frac{6 * \sum_{i=1}^{n} D_i^2}{(n^3 - n)} \quad (2)$$

$$t = R_{sp} * \sqrt{\frac{n-2}{1 - R_{sp}^2}} \quad (3)$$

Where:

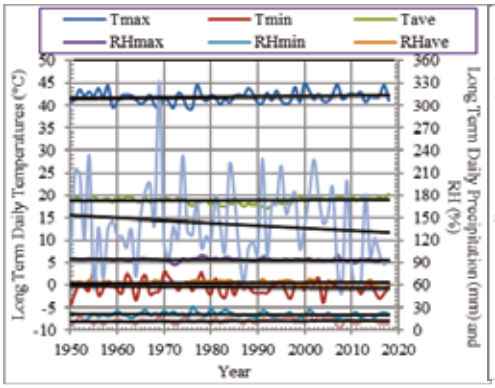
- n total observation order,
- i chronological rank number,
- D_i difference between rank (Kendall, 1975; Sneyers, 1990; Gauthier, 2001).

RESULTS AND DISCUSSIONS

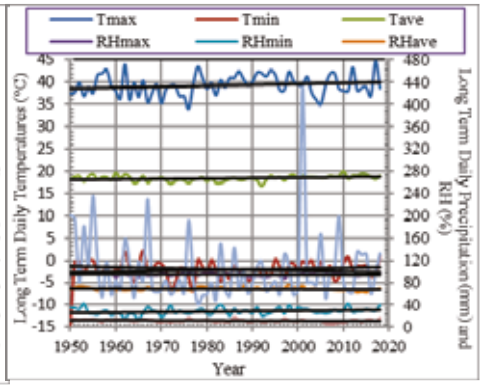
Parametric and non-parametric trend methods were preferred for determining the increase or decrease trends over time for the values of temperature (T_{MAX}, T_{MIN} and T_{AVE}), rainfall (P_{MAX}, P_{AVE}, P_T) and relative humidity (RH_{AVE}, RH_{MAX}, RH_{MIN}) used as meteorological variables in the study.

Figure 1 shows the graphic depiction for the meteorological variables for which a trend is determined in the cities as a result of the evaluations carried out according to LRA. Long term annual total rainfall variable trend in the studying area is presented in Figure 2.

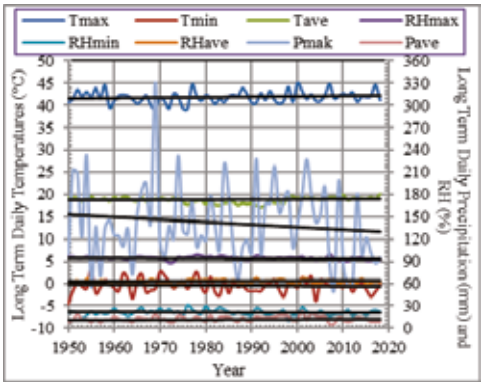
Adana



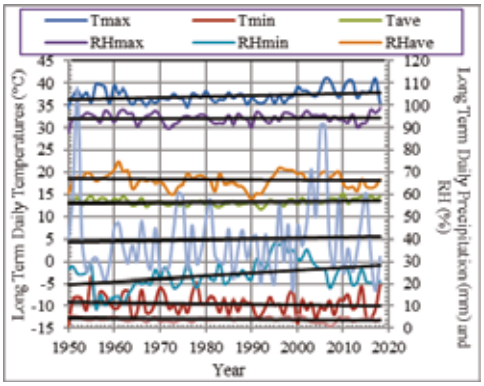
Antakya



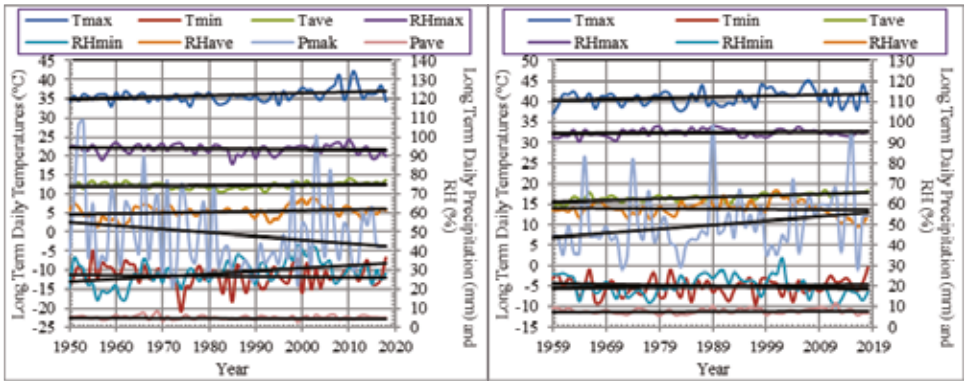
Antalya



Burdur



Isparta **Kahramanmaraş**



Mersin **Osmaniye**

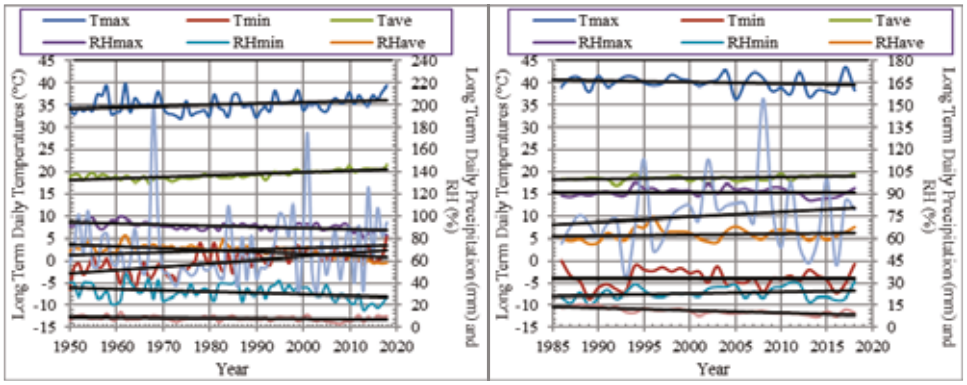


Figure 1. Trend Changes of Long-Term Meteorological Variables

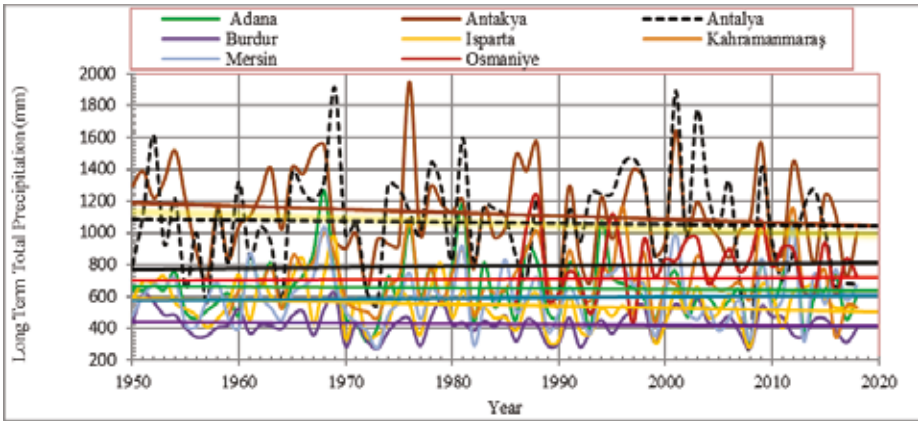


Figure 2. Long Term Annual Total Rainfall Variable Trend in Studying Area

Changes in the temperature values in the provinces respectively; T_{MAX} values in Mersin, Burdur, T_{MIN} values in Mersin, Adana, T_{AVE} values in Adana, Antalya, Kahramanmaras, Mersin and Osmaniye provinces have been determined to increase trends. It was found that RH_{MAX} values decreased in Mersin, RH_{MIN} values increased in Isparta, Burdur provinces and Mersin, Adana provinces decreased, RH_{AVE} values increased in Isparta, Antalya provinces and decrease in Mersin. In terms of P_{AVE} values, there are trends in the decreasing of Antakya, Osmaniye and Mersin provinces. It is stated that greenhouse gases released to the atmosphere are the fundamental causes of climate change (Bayraç & Doğan, 2016). Energy production and the burning of fossil fuels for heating purposes, industry, transportation, changes in land use, waste management and agricultural activities are among the primary activities that result in the increase of greenhouse gas emissions which cause global warming (Başoğlu, 2014; Bayraç & Doğan, 2016). It is put forth in general that human activities are the underlying factors for climate change (Black & Weisel, 2010; Başoğlu & Telatar, 2013; Başoğlu, 2014). It has been determined in general that there are trends for increasing temperature and decreasing rainfall in the study region. Başoğlu (2014) indicates that the first impacts of climate change appear with increasing temperatures and changes in rainfall regime. It is stated that excessive changes in these climate factors will result in the frequency and intensity of climate based natural disasters such as droughts, floods and storms thereby leading to economic losses. Since the agricultural sector is especially related with climate and weather conditions, researchers put forth that the impact of climate change on agriculture is much greater in comparison with other sectors (Bazzaz & Sombroek, 1996; Başoğlu & Telatar, 2013). Whereas Türkeş (1996) carried out a study on rainfall as a result of which it was presented that the annual rainfall values for our country have a tendency to decrease. Demir et al. (2017) indicates that temperatures are increasing in recent years and that rainfall amount continues to decrease. Therefore, it was determined in this study that there are trends related with temperature and rainfall. It was also observed that the aforementioned changes in temperature and rainfall specified in the literature are in accordance with the findings of the present study. Linear regression analysis and statistical features are given in Table 2.

Table 2. Linear regression analysis results and statistical features

Meteorological Stations/Variables	Equation coefficients		r	s	t	p (≤ 0.05)
	a	b				
Daily Maximum Temperature (T_{MAX}, °C)						
Adana	59.81	-0.01	0.104	1.92858	-0.86	0.394
Antakya	3.05	0.01828	0.158	2.29993	1.31	0.193
Antalya	21.18	0.01043	0.154	1.35644	1.27	0.208
Burdur	-10.41	0.024	0.301	1.53869	2.58	0.012
Isparta	-28.29	0.03233	0.379	1.50968	3.54	0.001
Kahramanmaraş	-9.34	0.02533	0.234	1.85151	1.84	0.072
Mersin	-13.4	0.02449	0.260	1.83697	2.21	0.031
Osmaniye	120.0	-0.03994	0.218	1.75691	-1.24	0.223
Daily Minimum Temperature (T_{MIN}, °C)						
Adana	-45.37	0.02191	0.238	1.80734	201	0.049
Antakya	-34.66	0.01634	0.140	2.33737	1.16	0.252
Antalya	12.99	-0.006803	0.086	1.58938	-0.71	0.481
Burdur	18.60	-0.01421	0.126	2.26288	-1.04	0.303
Isparta	7.68	-0.0097	0.069	2.84573	-0.56	0.575
Kahramanmaraş	-29.29	0.01217	0.096	2.21985	0.74	0.465
Mersin	-156.0	0.07849	0.637	1.91866	6.77	0.0001
Osmaniye	0.36	-0.00211	0.010	2.12075	-0.05	0.957
Daily Average Temperature (T_{AVE}, °C)						
Adana	1.898	0.008753	0.344	0.482678	3.0	0.004
Antakya	2.249	0.008121	0.263	0.602270	2.23	0.029
Antalya	12.29	0.003265	0.098	0.671290	0.8	0.424

Burdur	-0.14	0.006777	0.191	0.702700	1.6	0.115
Isparta	-2.67	0.007524	0.198	0.753857	1.65	0.103
Kahramanmaraş	-60.57	0.03884	0.700	0.698962	7.54	0.0001
Mersin	-50.74	0.03528	0.749	0.631523	9.24	0.0001
Osmaniye	-27.8	0.02319	0.373	0.567276	2.24	0.033
Daily Maximum Relative Humidity (RH_{MAX}, %)						
Adana	83.64	0.00543	0.047	2.33732	0.38	0.702
Antakya	113.00	-0.0097	0.087	2.24875	-0.71	0.478
Antalya	129.50	-0.01776	0.158	2.25059	-1.31	0.196
Burdur	83.64	0.00543	0.047	2.33732	0.38	0.702
Isparta	117.4	-0.01189	0.095	2.50234	-0.79	0.434
Kahramanmaraş	59.02	0.01801	0.184	1.68995	1.43	0.158
Mersin	299.0	-0.1049	0.564	3.10876	-5.58	0.0001
Osmaniye	109.3	-0.00896	0.027	3.26442	-0.15	0.882
Daily Minimum Relative Humidity (RH_{MIN}, %)						
Adana	176.40	-0.07668	0.279	5.34149	-2.37	0.020
Antakya	-92.41	0.06056	0.198	6.05830	1.65	0.103
Antalya	43.68	-0.01102	0.058	3.79923	-0.48	0.633
Burdur	-232.7	0.1293	0.397	6.04955	3.54	0.001
Isparta	-247.8	0.1393	0.427	5.96686	3.86	0.0001
Kahramanmaraş	113.5	-0.04697	0.168	4.84917	-1.3	0.199
Mersin	286.6	-0.1286	0.354	6.87459	-3.1	0.003
Osmaniye	-207.1	0.115	0.258	4.23036	1.49	0.147
Daily Average Relative Humidity (RH_{AVE}, %)						
Adana	93.21	-0.01351	0.079	3.42272	-0.65	0.516
Antakya	116.20	-0.02388	0.157	3.03359	-1.30	0.197
Antalya	56.00	0.00371	0.028	2.60707	2.59	0.012
Burdur	93.21	-0.01351	0.079	3.42272	-0.65	0.516
Isparta	-33.77	0.04769	0.290	3.18743	2.48	0.016
Kahramanmaraş	91.67	-0.01702	0.082	3.65713	-0.62	0.535
Mersin	412.9	-0.1733	0.672	3.85777	-7.43	0.0001
Osmaniye	-88.2	0.07539	0.179	4.07798	1.01	0.320
Daily Maximum Precipitation (P_{MAX}, mm)						
Adana	62.4	0.0023	0.032	27.0197	0.01	0.989
Antakya	427.7	-0.1634	0.054	61.6534	-0.44	0.663
Antalya	824.9	-0.3447	0.130	52.9635	-1.08	0.286
Burdur	-25.3	0.0329	0039	17.1942	0.32	0.752
Isparta	414.7	-0.1843	0,.183	20.049	-1.52	0.133
Kahramanmaraş	-358.2	0.2052	0.245	14.3395	1.90	0060
Mersin	-189.0	0.1303	0.086	30.4455	0.71	0.481
Osmaniye	-613.2	0.3438	0.143	23.3561	0.81	0.427
Daily Average Precipitation (P_{AVE}, mm)						
Adana	-50.68	0.0294	0.334	1.67883	2.90	0.005
Antakya	79.55	-003432	0.089	2.36911	-2.40	0.019
Antalya	-9.35	0.01074	0.063	3.45219	0.51	0.608
Burdur	20.69	-0.008411	0.185	0.903605	-1.54	0.128
Isparta	5.99	-0.000537	0.010	1.03995	-0.09	0.932
Kahramanmaraş	-5.56	0.00672	0.087	1.3632	0.66	0.511
Mersin	64.31	-0.02847	0.283	1.95061	-2.41	0.018
Osmaniye	353.6	- 0.1712	0.745	1.50662	-6.22	0.0001
Yearly Average Precipitation (P_T, mm)						
Adana	1584.0	-0.471	0.050	191.047	-0.41	0.685
Antakya	5361.0	-2.138	0.156	273.545	-1.29	0.200
Antalya	2418.0	-0.682	0.041	332.291	-0.34	0.735
Burdur	1186.0	-0.384	0.092	84.444	-0.75	0.455
Isparta	2864.0	-1.169	0.170	137.273	-1.41	0.163
Kahramanmaraş	123.0	0.296	0.030	177.059	0.22	0.823
Mersin	-368.0	0.484	0.057	170.791	0.47	0.641
Osmaniye	-301.0	0.550	0.028	186.387	0.16	0.873

When the values obtained are examined in Table 2, it can be observed that there are statistically significant increases in daily T_{MAX} values in the cities of Burdur (0.024°C year^{-1}), Isparta (0.03233°C year^{-1}) and Mersin (0.02449°C year^{-1}), in T_{MIN} values in the cities of Adana (0.02191°C year^{-1}) and Mersin (0.07849°C year^{-1}), and in T_{AVE} values in the cities of Adana, (0.008753°C year^{-1}) Antakya (0.08121°C year^{-1}), Kahramanmaraş (0.03884°C year^{-1}), Mersin (0.03528°C year^{-1}) and Osmaniye (0.02319°C year^{-1}). Whereas it was determined that there was a statistically significant increase trend in the daily RH_{MAX} values in Mersin, daily RH_{MIN} values in Adana, Mersin, Burdur, Isparta and RH_{AVE} values in Antalya, Isparta, Mersin. The decreases in daily P_{AVE} values were observed to be statistically significant in the cities of Antakya (-0.03432 mm year^{-1}), Mersin (-0.02847 mm year^{-1}) and Osmaniye (-0.1721mm year^{-1}); while the increase trend in the city of Adana (0.0294 mm year^{-1}) was observed to be statistically significant.

Since in general the increase in temperature and decrease in rainfall are emphasized in this and other similar studies, we also tried to emphasize the values related with temperature and decrease in rainfall.

It was determined upon examining Figure 3 prepared for the Spearman trend test that there was an increase trend for T_{MAX} values in the cities of Mersin, Isparta, Burdur; an increase trend for T_{MIN} values in the city of Mersin and an increase trend for T_{AVE} values in the cities of Mersin, Kahramanmaraş, Adana, Antakya, Osmaniye. RH_{MAX} values were observed to decrease in the city of, RH_{MIN} values were observed to increase in the city of Isparta and decrease in the cities of Mersin, Adana, while RH_{AVE} values were observed to increase in the city of Isparta and decrease in the city of Mersin. With regard to rainfall, Spearman trend test put forth that there were significant trends for P_{AVE} values to increase in the cities of Adana, Kahramanmaraş and decrease in the cities of Osmaniye, Antakya.

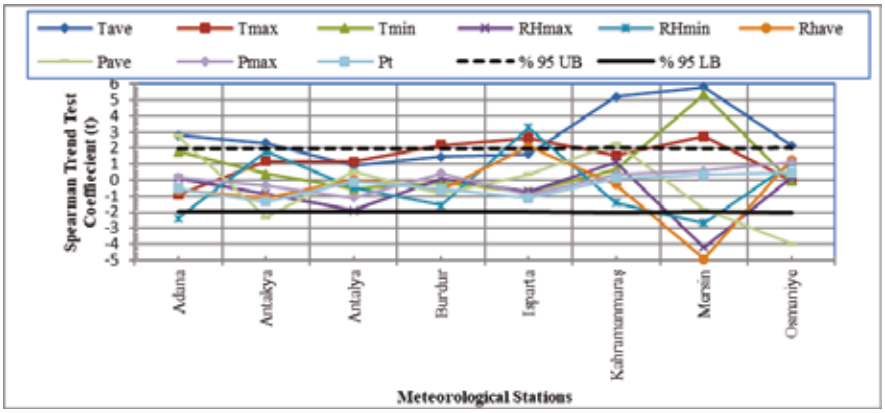


Figure 3. Results of Spearman Trend Test

CONCLUSIONS

The changes in the long-term temperature, rainfall and humidity values acquired from meteorological stations of the cities included in the study area were evaluated via LRA and STT. Therefore, it was determined that there were increasing and decreasing trends in the daily values for T_{MAX}, T_{MIN}, T_{AVE}, P_{AVE}, RH_{MAX}, RH_{MIN} and RH_{AVE} which were statistically significant.

High increases in temperature and decreases in rainfall as well as the changes in proportional humidity are indications that the climate of our region will be more arid in the coming years. When it is taken into consideration that intensive agricultural activities are carried out in the Mediterranean Region, it can easily be stated that there is an urgent need to replace all irrigation methods with pressurized irrigation methods. Because, the increase in temperature as well as the decrease in rainfall will further

increase the demands for our water resources. Moreover, it was also concluded that the changes in our water resources should also be examined and evaluated in addition to the changes in climate parameters. In this manner, water resource use can be planned more properly.

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