IJNES International Journal of Natural and Engineering Sciences 1 (3): 115-123, 2008
ISSN: 1307-1149, www.nobelonline.net

Trend Analysis for Examining the Interaction between the Atatürk Dam Lake and Its Local Climate

Hüsamettin BULUT, Bulent YESILATA*, M. Irfan YESILNACAR
Harran University, Faculty of Engineering, Osmanbey Campus, Şanlıurfa, Turkey.

*Corresponding Author
E-mail: byesilata@harran.edu.tr

Received: April 23, 2008
Accepted: July 25, 2008

Abstract

Large water reservoirs constructed for various purposes, such as dam lakes and ponds, affect climates of regions resulting in local climate variations. In this study, the effect of Atatürk Dam Lake, constructed in The Southeastern Anatolia Region of Turkey in 1986, on local climatic variables is examined. Long-term actual meteorological data for the nearest two sites to the Dam Lake, Şanlıurfa and Adıyaman, are considered. The three well-known and the most accessible techniques of trend analysis, linear regression, Mann-Kendall, and Sen's methods, are used for examining six meteorological variables of the sites. These variables are maximum temperature (Tmax), minimum temperature (Tmin), mean temperature (Tmean), relative humidity (RH), total precipitation (TP), and wind speed (WS). All the three techniques applied to climatic variables give the similar results of that there are upward trends in temperature and relative humidity, no trend in precipitation and decreasing trend in wind speed. These trends become more pronounced after the construction of the dam.

Keywords: Trend analysis; Climate change; Atatürk Dam Lake; GAP; Turkey.

INTRODUCTION

The impact of large water surfaces on the surrounding local climate is of both practical and scientific interest. The topic has thus been investigated by many researchers for some natural and artificial lakes or water reservoirs located in various regions of the world [1-8]. In Turkey, many hydroelectric plants with considerably large water surface area has been constructed in the last half century, and these water surfaces have caused in climatic variations in neighboring location, as reported by various researchers [9-12]. The impact of the Atatürk Dam Lake, constructed in the southeastern part of Turkey, on the regional climate has received relatively less attention, though it is the largest dam lake in Turkey and the sixth largest in the world. Few previous studies published in the last decade [13-17] could not provide enough information on the possible trends in climatic variables due to limited meteorological data insufficient for quantifying.

The main object of this paper is to apply some well-known and the most accessible quantitative techniques of trend analyses to examine impact of Atatürk Dam Lake on the regional climate. Since the effects of climate change can be directly seen in temperature, rainfall and wind speed [18], we consider here six meteorological variables of maximum temperature (Tmax), minimum temperature (Tmin), mean temperature (Tmean), relative humidity (RH), total precipitation (TP), and wind speed (WS). The two nearest sites to the lake, are Şanlıurfa (in the south) and Adıyaman (in the north) are selected for the analysis. The meteorological data for both sites are obtained from the Turkish State Meteorological Service (Turkish initials "DMİ") in electronic format for at least 26 years between 1972 and 2003. Table 1 provides geographical information for the sites and the data-period. The measurement devices and techniques are the same for both sites. For the trend analysis, Linear Regression, Mann-Kendall and Sen's Methods are used.

Table 1. Geographical information for locations and the periods of the weather data used in the present study.

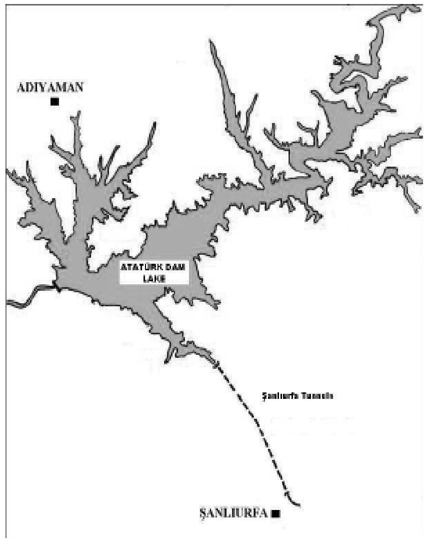
Location	Longitude	Latitude	Elevation	Climatic Variable	Period	Total years
Şanlıurfa	38° 46' E	37° 08' N	547 m	Tmax	1972-2003	32
				Tmin	1972-2003	32
				Tmean	1972-2003	32
				RH	1972-2003	32
				TP	1972-2003	32
				WS	1975-2003	29
Adıyaman	38° 17' E	37° 45' N	672 m	Tmax	1972-2001	30
				Tmin	1972-2001	30
				Tmean	1972-2001	30
				RH	1972-2001	30
				TP	1972-2001	30
				WS	1975-2000	26

STUDY AREA

The Southeastern Anatolia is one of the seven major geographical regions in Turkey and its location is shown in Figure 1 (a). The Southeastern Anatolia Project (Turkish initials 'GAP') is known to be not only Turkey's largest and most multifaceted development project, also one of the largest development projects of its kind in the world. The project area covers nine provinces (Adıyaman, Batman, Diyarbakır, Gaziantep, Kilis, Mardin, Siirt, Şanlıurfa and Şırnak) of the Southeastern Anatolia Region. The provinces are mainly located in the Euphrates-Tigris basins and Upper Mesopotamia plains, and have an area extending over 75 358 km^2, which corresponds to 9.7 % of the total area of Turkey. The project covers many sectors, such as irrigation, hydroelectric energy, agriculture, urban, rural and agricultural infrastructure, transportation, industry, forestry, tourism, education and health. Its water resources program envisages the construction of 22 dams and 19 power plants and irrigation schemes on an area extending over 1.7 million hectares. It will be possible to produce 27 billion kWh energy at an installed capacity of 7460 MW annually. The planned irrigation area corresponds to 20 % of total irrigable land in Turkey, while annual energy production will have a share of 22 % of total energy production capacity of Turkey (http://www.gap.gov.tr).

The Atatürk Dam Lake with its Hydroelectric Plant is the major foundation of GAP, and it is located in the Bozova town of Şanlıurfa. The Atatürk Dam is important for energy production, irrigation and water supply. Water obtained from the reservoirs on the Euphrates is carried to the Harran Plain by the Şanlıurfa Tunnels (http://www.mfa.gov.tr/grupc/ca/caa/uu/e1004.htm). The Dam Lake is in the border of two provinces, Şanlıurfa and Adıyaman, as shown in Figure 1(b). The corresponding distances between the dam and Şanlıurfa and Adıyaman city centers are respectively 62 km and 35 km. The dam was constructed between the years of 1983 and 1992 while water collection was started on 16 June 1986. Reservoir area and volume at normal water surface elevation are 817 km^2 and 48 700 hm^3, respectively (http://www.dsi.gov.tr/tricold/ataturk.htm). The present study investigates the effect of Atatürk Dam Lake on local climate of both Şanlıurfa and Adıyaman provinces since the lake is located in the very near border of these provinces. The other neighbor locations that could additionally be considered have presently no enough data for the long-term analysis and thus they are not a part of the main analysis.

(a)



(b)

Figure 1. (a) Map of Turkey with the location of the GAP region, (b) Location of study area.

TREND ANALYSIS OF METEOROLOGICAL VARIABLES

In statistical terms, the purpose of trend analysis is to determine if a series of observations of a random variable is generally increasing or decreasing with time, or whether the probability distribution has changed with time [19]. Numerous long-term atmospheric variables and global climate change must be taken into account to determine or claim apparent climate change for the region under consideration. Well-established trend analysis methods are also crucial to estimate the degree of this effect.

Several tests are available for the detection and/or quantification of trends. Graphical, linear regression, Mann-Kendall, and Sen's methods are main techniques for detecting and/or estimating trends. In this study, these methods are applied to monthly and yearly Tmin, Tmax, Tmean, RH, TP and WS for Şanlıurfa and Adıyaman. The graphical method is not included in detail here as it is already a portion of the methods explained below and is also subject of a forthcoming study being carried out by the same authors.

Linear regression analysis of meteorological variables

Linear regression analysis is an extremely useful and simple tool for estimating an unknown trend. The trend function is generally a linear function of two parameters, β_0 and β_1 and the general form of the model is given by

$$y = \beta_0 x + \beta_1 \quad \textbf{(1)}$$

where β_0 describes direction and magnitude of the slope, and β_1 is the y-intercept of the line. β_0 also represents the average changing rate of the variable. A positive value of β_0 indicates an upward trend and a negative value indicates a downward trend. If β_0 is not significantly different from zero, there is no trend in the variable.

In this study, the Student's 't-test' was used to test whether a linear trend is statistically significant. The estimated slopes were tested using the hypothesis of null slope by means of the two-tailed 't-test' at a confidence level of 95% (α = 0.05). The null hypothesis (no trend) should be accepted if $-t_{\alpha/2} \leq t \leq t_{\alpha/2}$, where $t_{\alpha/2}$ is obtained from the t-distribution table with (n-2) degrees of freedom.

The 't-test' results of yearly trend equations for meteorological data of both Şanlıurfa and Adıyaman are given in Table 2 and Table 3. The linear regression parameters of β_0, β_1, and R^2, the determination-coefficient or the root mean square error (RMSE) are also included in the tables. As seen in Tables 2 and 3, for both provinces, the slopes of trend equations are positive for all climate variables other than WS, for which a negative slope is obtained. At southern location, Şanlıurfa, the trend of the variables with positive slope is statistically significant according to two-tailed t-test at confidence level of 95%. The same test indicates that the trend of WS is statistically insignificant. The situation is somewhat different for northern station, Adıyaman: the estimated trends in Tmin, Tmean and TP are found to be statistically insignificant whereas it is significant for the other variables.

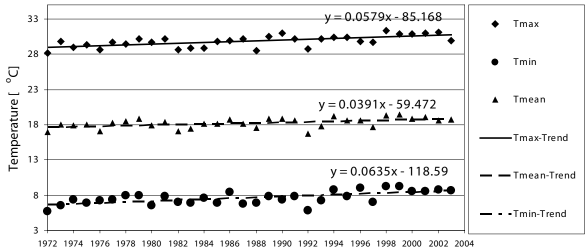
Table 2. The parameters (β_0 and β_1), R^2, RMSE and t-test results of yearly trend equations of meteorological data for Şanlıurfa.

Climatic Variable	β_0	β_1	R^2	RMSE	t	$t_{\alpha/2 = 0.025}$	Hypothesis
Tmax	0.058	-85.168	0.413	0.658	4.591	2.042	Reject
Tmin	0.064	-118.594	0.397	0.746	4.446	2.042	Reject
Tmean	0.039	-59.472	0.272	0.609	3.352	2.042	Reject
RH	0.237	-419.003	0.393	2.810	4.408	2.042	Reject
TP	0.010	16.988	0.0001	11.073	0.048	2.042	Accept
WS	-0.001	4.087	0.001	0.367	-0.151	2.052	Accept

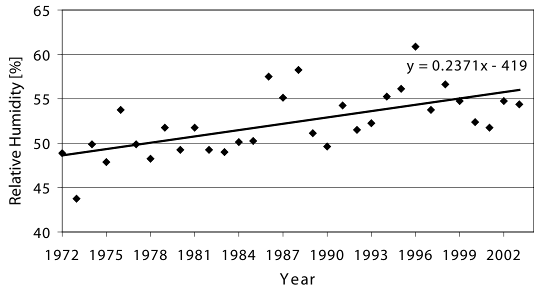
Table 3. The parameters (β_0 and β_1), R^2, RMSE, and t-test results of yearly trend equations of meteorological data for Adıyaman.

Climatic Variable	β_0	β_1	R^2	RMSE	t	$t_{\alpha/2 = 0.025}$	Hypothesis
Tmax	0.077	-124.055	0.469	0.732	4.972	2.048	Reject
Tmin	0.038	-68.711	0.084	1.124	1.597	2.048	Accept
Tmean	0.026	-34.939	0.117	0.645	1.924	2.048	Accept
RH	0.328	-602.223	0.315	4.335	3.591	2.048	Reject
TP	0.166	-273.437	0.01	14.7	0.537	2.048	Accept
WS	-0.032	66.613	0.838	0.112	-11.132	2.064	Reject

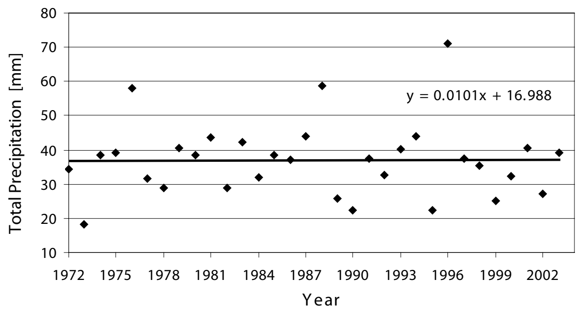
The variation of yearly mean values of temperatures and trend function are shown in Figure 2(a) for Şanlıurfa. The visual inspections of the trends show that there are upward trends in Tmin, Tmax and Tmean. The trend equations for yearly mean values of RH, TP and WS for Şanlıurfa are respectively depicted in Figures 2(b) through 2(d). The trend appearance in the relative humidity supports the trends in Tmin, Tmax and Tmean shown in Figure 2(a), in the sense that increase in temperature results in increase in the evaporation and in RH. The TP has rather random scatter with years but the WS persist with time. It can be concluded that there are insignificant variations in TP and WS but a drastic increase in RH. The plots obtained for Adıyaman province show quite similar trends as illustrated in Figure 3 (a-d). There are increasing trends in temperatures and RH. No apparent change in TP and a decrease in WS can be observed from the plots. The RH trend at Adıyaman location has more scatter around the trend line, which indicates variability in climate in addition to annual increasing trend. The variations are larger than those of Şanlıurfa station although they have almost the same averages. The average value of TP is higher for Adıyaman since it is located in relatively higher elevation than Şanlıurfa.



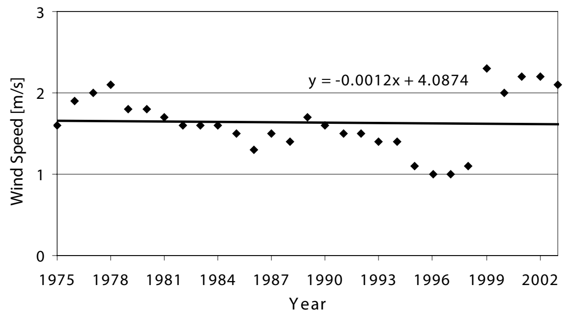
(a)



(b)

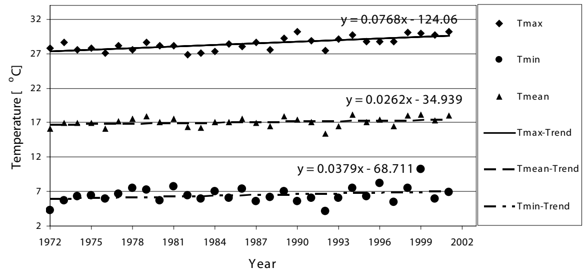


(c)

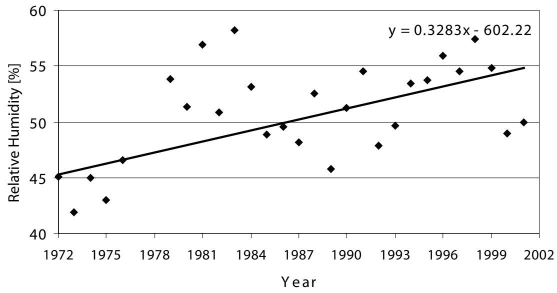


(d)

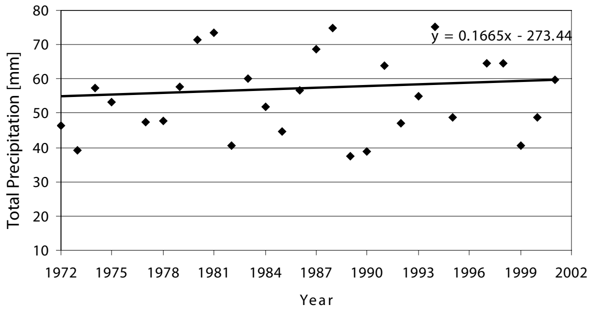
Figure 2. Variation of yearly mean values of climatic variables and their trend equations for Şanlıurfa; (a) Tmax, Tmin and Tmean, (b) RH, (c) TP, (d) WS.



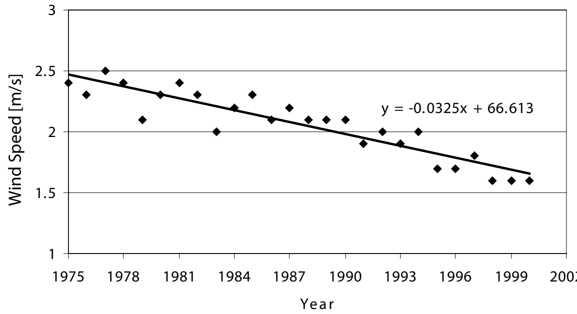
(a)



(b)



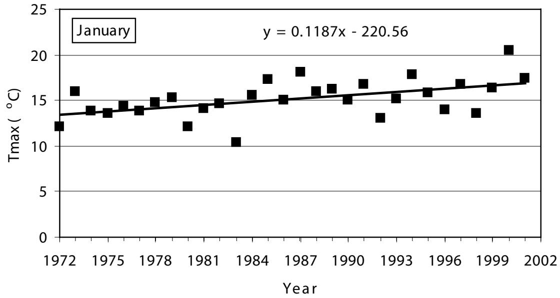
(c)



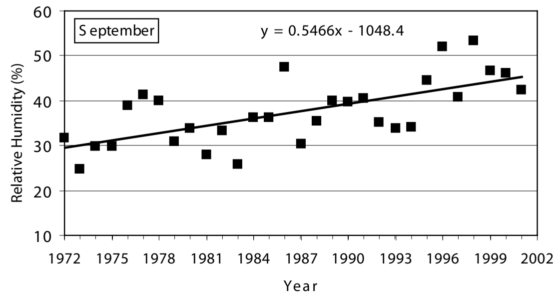
(d)

Figure 3. Variation of yearly mean values of climatic variables and their trend equations for Adıyaman; (a) Tmax, Tmin and Tmean, (b) RH, (c) TP, (d) WS.

Monthly trend equation of each meteorological variable was also determined. The two-tailed t-test was performed on each monthly meteorological variable at a confidence level of 95%. The general frame of this monthly analysis of meteorological variables agrees that the null hypothesis (no trend) is accepted for WS and TP in all months of the year for Şanlıurfa, but there is significant trend for WS in almost all months for Adıyaman. The monthly trend analyses of meteorological data also show that the high values of R^2 are consistent with rejection of null hypothesis. As an example of illustrating monthly trends, the test results for Tmax (in January) and RH (in September) are shown in Figures 4 and 5 respectively for both Şanlıurfa and Adıyaman climate stations. January for Tmax and September for RH are selected because the significant trends for the selected climatic variables are observed to happen in these months. The slope of Tmax trend line is slightly lower for Şanlıurfa as can be seen from Figures 4(a) and 5(a). On the other hand, the slopes of RH trend lines given in Figures 4(b) and 5(b) significantly differ, in favor of Şanlıurfa station.

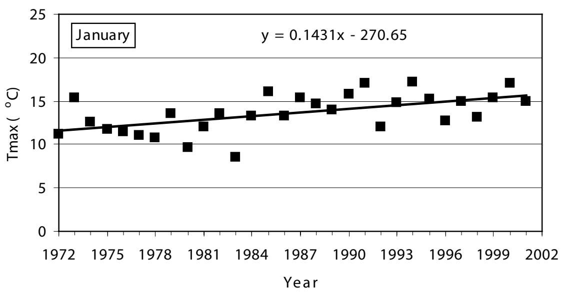


(a)

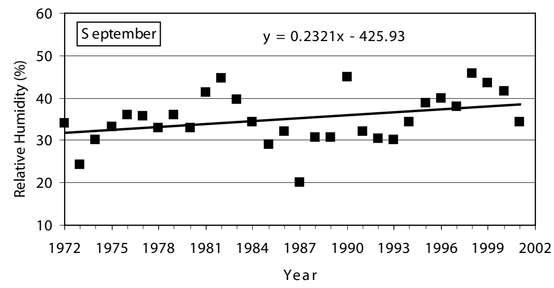


(b)

Figure 4. Variation of monthly mean values of some climatic variables for Şanlıurfa; (a) Tmax and its trend for January, (b) RH and its trend for September.



(a)



(b)

Figure 5. Variation of monthly mean values of some climatic variables for Adıyaman; (a) Tmax and its trend for January, (b) RH and its trend for September.

Analysis of meteorological variables with Mann-Kendall trend test

Mann-Kendall method [20, 21] is one of the widely used non-parametric test for detecting trends in climatological and hydrological time series. It has been suggested by The World Meteorological Organization (WMO) to assess the trend in environmental data time series. The method is simple, robust and handles missing values and values below a detection limit [22-27]. The Mann- Kendall test statistic S is given by,

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sign(x_j - x_i) \tag{2}$$

where n is number of data, x is data point at times i and j ($j > i$), and the sign function is

$$sign(x_j - x_i) = \begin{cases} +1 & x_j > x_i \\ 0 & x_j = x_i \\ -1 & x_j < x_i \end{cases} \tag{3}$$

The variance of S is computed by

$$Var(S) = \left[n(n-1)(2n+5) - \sum_{i=1}^{m} t(t-1)(2t+5) \right] / 18 \tag{4}$$

where t is the number of tied group and m is the number of tied values. For n larger than 10, the standard normal Z test statistic is computed as Mann- Kendall test statistic as follows,

$$Z = \begin{cases} \dfrac{S-1}{\sqrt{Var(S)}} & S > 0 \\ 0 & S = 0 \\ \dfrac{S+1}{\sqrt{Var(S)}} & S < 0 \end{cases} \tag{5}$$

The presence of a statistically significant trend is evaluated using the Z value. This statistic is used to test the null hypothesis of no trend. A positive Z indicates an increasing trend in the time-series, while a negative Z indicates a decreasing trend. In a two-sided test, to confirm for either increasing or decreasing monotonic trend at α significance level, the null hypothesis should be accepted if $-Z_{1-\alpha/2} \leq Z \leq Z_{1-\alpha/2}$, where $Z_{1-\alpha/2}$ is obtained from the normal cumulative distribution tables.

The significance levels of α = 0.1 and α = 0.05 were applied for each analyzed monthly and yearly meteorological data series in this work. Table 4 gives the test results of Mann-Kendall method applied to yearly meteorological variables for Şanlıurfa. Upward trend is detected in temperatures and RH at confidence interval of 95% (α = 0.05) and 90% (α = 0.10). However, insignificant trends in TP and WS are obtained. The Mann-Kendall test results of yearly meteorological data for Adıyaman are given in Table 5. Under the same two-sided confidence intervals, no trend for Tmin and TP, upward trend in Tmax, Tmean and RH, and finally downward trend in WS can be observed. Additional analyses on the monthly mean values of climatic variables for both provinces were also performed by using Mann-Kendall method. The obtained results are found to be in good agreement with the ones previously obtained from the linear regression analysis.

Table 4. The test results of Mann-Kendall Methods for Şanlıurfa

Climatic Variable	S	Var (S)	Z	$Z_{0.95}$	$Z_{0.975}$	Hypothesis
Tmax	238	3784.667	3.852	1.645	1.96	Reject
Tmin	211	3781.667	3.415	1.645	1.96	Reject
Tmean	189	3777.667	3.059	1.645	1.96	Reject
RH	239	3797.667	3.862	1.645	1.96	Reject
TP	-1	3799.667	0.000	1.645	1.96	Accept
WS	-78	2806.000	-1.454	1.645	1.96	Accept

Table 5. The test results of Mann-Kendall Methods for Adıyaman

Climatic Variable	S	Var (S)	Z	$Z_{0.95}$	$Z_{0.975}$	Hypothesis
Tmax	209	3131.000	3.717	1.645	1.96	Reject
Tmin	57	3128.333	1.001	1.645	1.96	Accept
Tmean	124	3116.000	2.203	1.645	1.96	Reject
RH	164	3140.667	2.909	1.645	1.96	Reject
TP	44	3140.667	0.767	1.645	1.96	Accept
WS	-247	2019.000	-5.475	1.645	1.96	Reject

The trend analysis of meteorological variables with Sen's Method

If a linear trend is present in a time series, the magnitude of the slope of trend can be estimated by using a simple non-parametric procedure developed by Sen [28]. The test procedure is given below in detail [26, http://www.cee.vt.edu/program_areas/environmental/teach/smprimer/sen/sen.html].

If there is n total data in a series, the slopes estimated are N pairs:

$$N = n(n-1)/2 \tag{6}$$

The magnitude of slope, β, is given for N pairs of data as follow,

$$\text{b} = Median\left[Q_i = \frac{X_j - X_k}{j-k} \right] \tag{7}$$

where $i = 1 \ldots N$ and X is data at times j and k with $j > k$.

Sen's method also allows determination of whether the median slope is statistically different from zero. A confidence interval is developed by estimating the rank for the upper and lower confidence interval. Using the slopes corresponding to these ranks defines the actual confidence interval for β. For a two-sided confidence interval about the median slope, first the Z for a two-tailed normal distribution test is computed. For example, for confidence interval of 95% (α = 0.05), Z is $Z_{1-0.05/2} = Z_{0.975} = 1.96$ and for 90% (α = 0.10) confidence, Z is $Z_{1-0.1/2} = Z_{0.95}$. The variance of the Mann-Kendall statistic, VAR (S), can then be computed from Equation 4. The ranks of the lower ($M1$) and upper ($M2$ + 1) confidence limits are given by

$$M1 = \frac{N-C}{2} \tag{8}$$

$$M2 = \frac{N+C}{2} \tag{9}$$

where N is total pairs of data and found in equation X. C is given by.

Table 6. The Sen's Slope**,** β for climatic variables of Şanlıurfa and the slopes at the ranks of the lower and upper confidence limits for confidence intervals of 95% and 90%.

Climatic Variable	β	$Z_{0.95}$ M1 Slope	$Z_{0.95}$ M2 Slope	$Z_{0.975}$ M1 Slope	$Z_{0.975}$ M2 Slope
Tmax	0.061	0.041	0.076	0.038	0.083
Tmin	0.066	0.042	0.091	0.033	0.100
Tmean	0.040	0.022	0.057	0.020	0.059
RH	0.231	0.137	0.300	0.126	0.314
TP	0.000	-0.317	0.280	-0.396	0.370
WS	-0.018	-0.033	0.000	-0.036	0.004

Table 7. The Sen's Slope**,** β for climatic variables of Adıyaman and the slopes at the ranks of the lower and upper confidence limits for confidence intervals of 95% and 90%.

Climatic Variable	β	$Z_{0.95}$ M1 Slope	$Z_{0.95}$ M2 Slope	$Z_{0.975}$ M1 Slope	$Z_{0.975}$ M2 Slope
Tmax	0.079	0.050	0.100	0.044	0.108
Tmin	0.025	-0.011	0.072	-0.014	0.080
Tmean	0.025	0.009	0.050	0.000	0.056
RH	0.355	0.161	0.490	0.140	0.500
TP	0.200	-0.373	0.704	-0.414	0.837
WS	-0.033	-0.040	-0.027	-0.040	-0.025

$$C = Z_{1-a/2}\sqrt{VAR(S)} \quad \textbf{(10)}$$

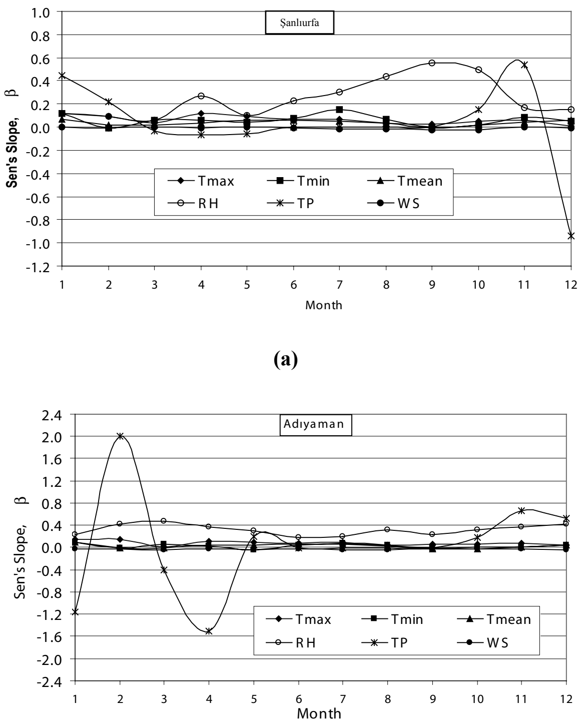
Finally, the slopes corresponding to *M1* and *M2*+1 are chosen as the lower and upper confidence limits, respectively. Note that the median slope is then defined as statistically different from zero (for the selected confidence interval) if the zero does not lie between the upper and lower confidence limits.

The Sen's method was also applied to six meteorological variables for both sites, as previously done with the other methods of trend analysis. The results are given in Table 6 and Table 7 with the same order. Table 6 shows that the slopes for median temperatures and RH are different from zero and positive for Şanlıurfa in two confidence intervals. The slope of TP is zero indicating no change, and WS is decreasing. Similarly, the slopes of temperatures and RH are positive and that of WS is negative for Adıyaman, as seen in Table 7. However, TP has a positive slope for this site.

Figure 6(a) shows variation of the slopes for the monthly values of meteorological variables for Şanlıurfa. The slopes of RH and temperatures for all months are positive, and WS-slopes are around zero. There are significant fluctuations on the slope estimators of TP. The variation of meteorological slopes for Adıyaman is illustrated in Figure 6(b). For this site, the slopes of RH are also found to be always positive. TP slope estimators are observed to fluctuate in a similar manner. However, a slight decreasing tendency in WS is realized.

DISCUSSION AND FINDINGS

The results of the methods used in the present study in terms of annual mean climatic variables for both sites are summarized in Table 8. It is evident from this table that all the three trend analyses outlined above lead to nearly identical results for the climatic variables under examination. Results from the different methods generally agree that temperature and relative humidity have been increasing, and wind speed has been decreasing, at 2 locations in this region over about the last 30 years.



(a) (b)

Figure 6. Variation of the slopes for the monthly mean meteorological variables for (a) Şanlıurfa, (b) Adıyaman.

There is also need to consider the regional climate prior to and after the existence of the dam (before 1986 and after 1992), to see if there is any significant changes in meteorological variables. The whole period (1972-2003) is thus divided into three different parts. The first period (I.P) is before the reservoir filling, 1972-1986, and the second period (II.P) is after the dam built, 1992-2003. In order to see effect of reservoir filling as well as dam construction on the regional climate, a transition period (TP) is defined, which covers years 1987-1991 between the first and second periods. This intervention approach has earlier been used by the same authors and more details are given elsewhere [29].

Table 8. The summary of the test results of annual mean climatic variables for Şanlıurfa and Adıyaman

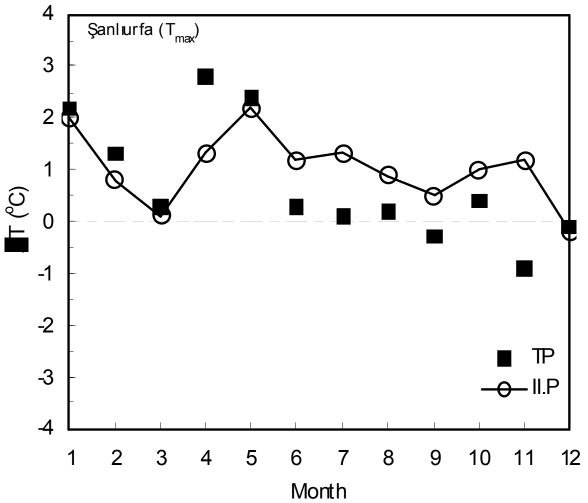
Climatic Variable	Linear Regression Şanlıurfa	Linear Regression Adıyaman	Mann-Kendall Şanlıurfa	Mann-Kendall Adıyaman	Sen's Şanlıurfa	Sen's Adıyaman
Tmax	+	+	+	+	+	+
Tmin	+	+	+	O	+	+
Tmean	+	+	+	+	+	+
RH	+	+	+	+	+	+
TP	+	+	O	O	O	+
WS	-	-	-	-	-	-

+: upward trend, -:downward trend, O: no trend

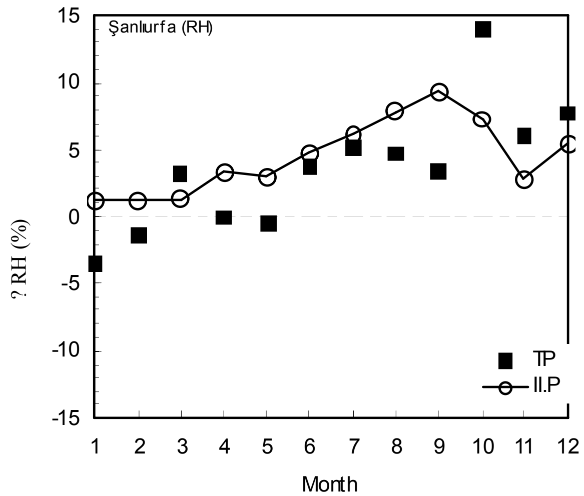
The mean monthly trends of two climatic variables, maximum temperature (Tmax) and relative humidity (RH) are examined here for both weather stations. The variation of selected climatic variable during the second period is determined with the following formula,

$$\Delta X = (\overline{X})_{II.P} - (\overline{X})_{I.P} \tag{11}$$

where $\overline{X}$ mean monthly values of the selected climatic variable (Tmax or RH). For example, considering Tmax, any change between the second and first periods can be confirmed if $\Delta T = (\overline{T}_{\max})_{II.P} - (\overline{T}_{\max})_{I.P} \neq 0$. The same approach is valid for transition period, and subscript for the second period must be replaced with that of transition period. The results are presented in Figure 7 and Figure 8, respectively for Şanlıurfa and Adıyaman weather stations.

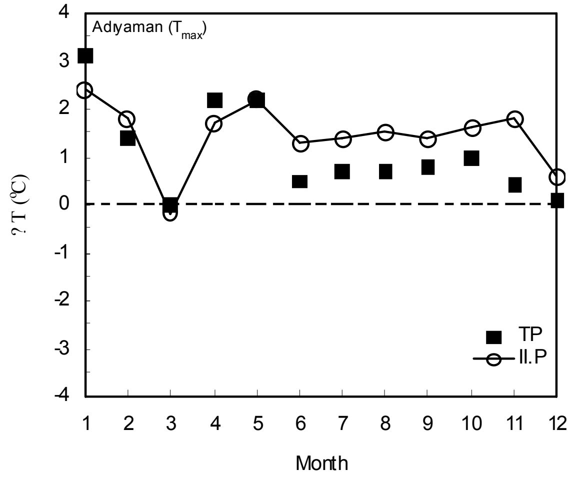


(a)

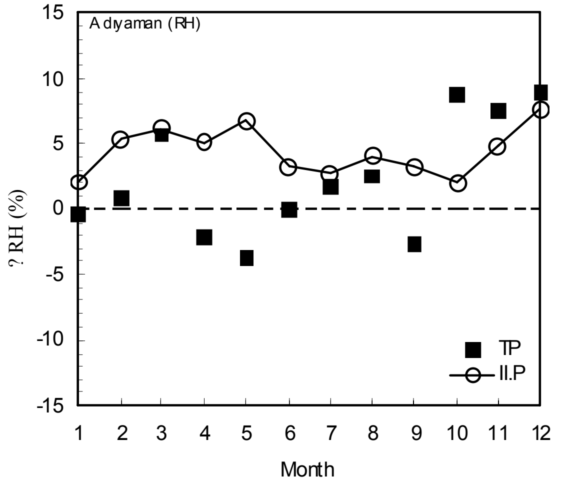


(b)

Figure 7. The comparison of meteorological data in the transition (TP) and second (II.P) periods for Şanlıurfa (a) Tmax, (b) RH.



(a)



(b)

Figure 8. The comparison of meteorological data in the transition (TP) and second (II.P) periods for Adıyaman (a) Tmax, (b) RH.

In general, there are impacts of the reservoir in both the transition and the second periods. The climatic variables scatter from one month to the other in transition period. A drastic increase can be observed for some months. In the second period, more stable and definite increase on both Tmax and RH are obtained for both weather stations. The absence of parallelism between these two periods might be due to two factors. First, the water-level and water surface area in the reservoir were continuously varied during dam construction whereas they remained nearly constant after 1992. The second factor is initiation of significant irrigation in the region at the end of 1994. This could cause in two effects in play; the direct impact of the large reservoir surface as well as surface albedo, moisture and energy flux changes associated with the movement away from relatively sparse or barren landcover conditions to more lush irrigated agriculture. Presence of these two effects together in the second period appear to be one of the main reasons for obtaining more definite increase on both climatic variables for almost all months of the year.

It is possible that there might be some additional factors affecting the regional climate; such as anthropogenic landuse/

landcover change and global climate change. The present analyses only demonstrate that the dam reservoir has significant effect on local climate changes. An extensive analysis should be carried out in future with suitable and enough data by considering all aspects including global climate change.

CONCLUSION

Linear regression, Mann-Kendall and Sen's methods are used for trend analysis to examine the impacts of Atatürk Dam Lake on the climate of the region. The six climatic variables for Şanlıurfa and Adıyaman provinces are considered. All methods applied to these climatic variables consistently show that maximum temperature (Tmax), minimum temperature (Tmin), mean temperature (Tmean), and relative humidity (RH) increase for both sites. In contrast, wind speed (WS) decreases and total precipitation (TP) remains unchanged. The impact of Atatürk Dam water reservoir on these trends appears to be significant.

The present study is just a preliminary stage for careful monitoring and assessment of the meteorological data in the region. Meteorological station network should be expanded for the region. It is hoped that an extended analysis of this work will be performed when more data become available.

Acknowledgements

This study was supported by the Scientific Research Projects Committee of Harran University (Project no: HÜBAK-443). The authors wish to express their gratitude to DMİ for providing meteorological data. We also would like to thank to Professor Zekai ŞEN, İstanbul Technical University, for his valuable suggestions.

REFERENCES

[1] Bates GT, Giorgi F, Hosteller SW. 1993. Toward the Simulation of the effects of the great lakes on regional climate. Monthly Weather Review 212: 1373-1387.

[2] Bates GT, Hostetler SW, Giorgi F. 1995. 2-year simulation of the great-lakes region with a coupled modeling system. Monthly Weather Review 123 (5): 1505-1522.

[3] Lofgren BM. 1997. Simulated Effects of idealized Laurentian great lakes on regional and large-scale climate. Journal of Climate 10(11): 2847-2858.

[4] Hostetler SW, Small EE. 1999. Response of North American freshwater lakes to simulated future climates. Journal of the American Water Resources Association 35(6): 1625-1637.

[5] Hostetler SW, Bartlein PJ, Clark PU, Small EE, Solomon AM. 2000. Simulated influences of Lake Agassiz on the climate of Central North America 11,000 Years Ago. Nature 405(6784): 334-337.

[6] Small EE, Sloan LC, Nychka D. 2001. Changes in surface air temperature caused by desiccation of the Aral Sea. Journal of Climate 14(3): 284-299.

[7] Delcourt PA, Nester PL, Delcourt HR, Mora CI, Orvis KH. 2002. Holocene lake-effect precipitation in Northern Michigan. Quaternary Research 57: 225–233.

[8] Krinner G. 2003. Impact of lakes and wetlands on Boreal climate. Journal of Geophysical Research-Atmospheres 108(D16): art. no. 4520.

[9] Tonbul S. 1986. Climate features of Elazığ and its surroundings and effects of Keban dam on regional climate. in Proceeding of Geography Symposium, Fırat University, Elazığ, Turkey, pp. 275-292. (in Turkish)

[10] Güldal V, Ağıralioğlu N. 1994. Effect of dam reservoirs. in Proceedings of Improvement Water and Soil Resources Conference, Turkish Ministry of Reconstruction and Settlement, Directorate of state water affairs, Ankara, Turkey, pp. 417-435. (in Turkish).

[11] Kadıoğlu M, Satılmış S, Özgüler H. 1994. The Effect of Big Water Mass on Environment Climate. in Proceedings of Improvement Water and Soil Resources Conference, Turkish Ministry of Reconstruction and Settlement, Directorate of state water affairs, Ankara, Turkey, pp. 1099-1108. (in Turkish)

[12] Emiroğlu ME, Özkan F, Öztürk M. 1996. A research on the effect of Keban dam reservoir on climatic conditions of Elazığ province. in Proceedings of First GAP Engineering Congress, Harran University, Şanlıurfa, Turkey, pp. 167-174. (in Turkish).

[13] Biçer Y, Yıldız C. 1994. Investigation of the effect of Atatürk dam reservoir on outdoor temperature parameter of Şanlıurfa province. in Proceedings of 3rd National Congress on Cooling and Air-Conditioning Techniques, Çukurova University, Adana, Turkey, pp. 333-340. (in Turkish).

[14] Biçer Y, Yıldız C. 1996. The effect of dam reservoir in the Euphrates basin on outdoor temperatures of provinces located in the region. in Proceedings of first GAP Engineering Congress, Harran University, Şanlıurfa, Turkey, pp. 175-180. (in Turkish).

[15] Bulut H, Şenocak Mİ, Karasu H.1996. Climate file of Şanlıurfa. in Proceedings of First GAP Engineering Congress, Harran University, Şanlıurfa, Turkey, pp. 151-159. (in Turkish).

[16] Yeşilnacar Mİ, Gülşen, H. 1999. Climatic characteristics of Şanlıurfa and its surroundings and effects of Atatürk Dam on regional climate. in Proceeding of 52nd Geological Congress of Turkey, Ankara, Turkey, pp. 122-128. (in Turkish)

[17] Yeşilata B, Aktacir A. 2001. A study on psychrometric changes resulting from artificial water mass', Termodinamik 106: 56-60. (in Turkish)

[18] Schwalm CR, Ek AR. 2001. Climate change and site: relevant mechanisms and modeling techniques. Forest Ecology and Management 150: 241–257.

[19] Helsel DR, Hirsch RM. 1992. Statistical Methods In Water Resources. Elsevier Publishers: Amsterdam.

[20] Mann HB. 1945. Non-parametric test against trend. Econometrika 13: 245-259.

[21] Kendall, MG.1975. Rank correlation methods. Charles Griffin: London.

[22] Hamed KH, Rao AR. 1998. , 'A modified Mann-Kendall trend test for autocorrelated data. Journal of Hydrology 204: 182–1196.

[23] Kosif K. 2001. Climate trends in Samsun province. Technical Bulletin of DSİ 98: 3-13. (in Turkish)

[24] Burn DH, Elnur MAH. 2002. Detection of hydrologic trends and variability. Journal of Hydrology 255: 107–122.

[25] Xu ZX, Takeuchi K. Ishidaira H. 2003. Monotonic trend and step changes in Japanese precipitation. Journal of Hydrology 279: 144-150.

[26] Kahya E, Kalaycı S. 2004. Trend analysis of streamflow in Turkey. Journal of Hydrology 289: 128–144.

[27] Silva VPR. 2004. On climate variability in northeast of Brazil. Journal of Arid Environments 58(4): 575-596.

[28] Sen PK. 1968. Estimates of the regression coefficient based on Kendall's tau. Journal of American Statistical Association 39: 1379–1389.

[29] Yeşilata B, Bulut H, Yeşilnacar Mİ. 2004. Investigation of changes in temperature and humidity parameters of GAP region resulting from Atatürk Dam Lake. Journal of HVAC and Sanitary Engineering 83: 21-31. (in Turkish)