# Chapter 3

# TREND ANALYSIS of MEAN TEMPERATURES DATA in VAN LAKE CLOSED BASIN, TURKEY

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## 1. INTRODUCTION

The earth, consisting of five basic components called atmosphere, hydrosphere, cryosphere, lithosphere and biosphere, constitutes a complex system called the global climate system (Turkes, 2012). Climate can be defined as the repetition of atmospheric events of similar character throughout the year as a result of measuring the average, maximum, minimum and extreme values of climate elements for long-term measurements in extended specific areas. The climate has a variable structure and can be influenced by many factors and may change existing character in the time (Turkes et al., 2000; Atalay, 2010).

The issue of climate change has been well documented in the academic literature of Turkey and the world and very serious studies have been carried out on this issue. Turkey, one of the central latitude countries, is expected to be affected by climatic change and will experience the impact of the drought problem severely.

The most important parameters of climate elements are temperature and precipitation. In recent years, changes in temperature and rainfall values are being investigated extensively.

The average temperature values in Turkey have been found to show warming trends in eastern Anatolia region as a result of long-term examinations of temperature values from 1930 to 1993. While there are warming trends in the Eastern Anatolia region, a cooling trend in temperature values is observed in the coastal areas (Turkes et al., 1995). In a study addressing the spatial and temporal tendencies of average, minimum and maximum temperatures, Turkes et al. (2002) found that cities are warmer than their surroundings due to the ongoing migration towards cities, rapid urbanization, industrialization, use of concrete and increased greenhouse gases in a particular area.

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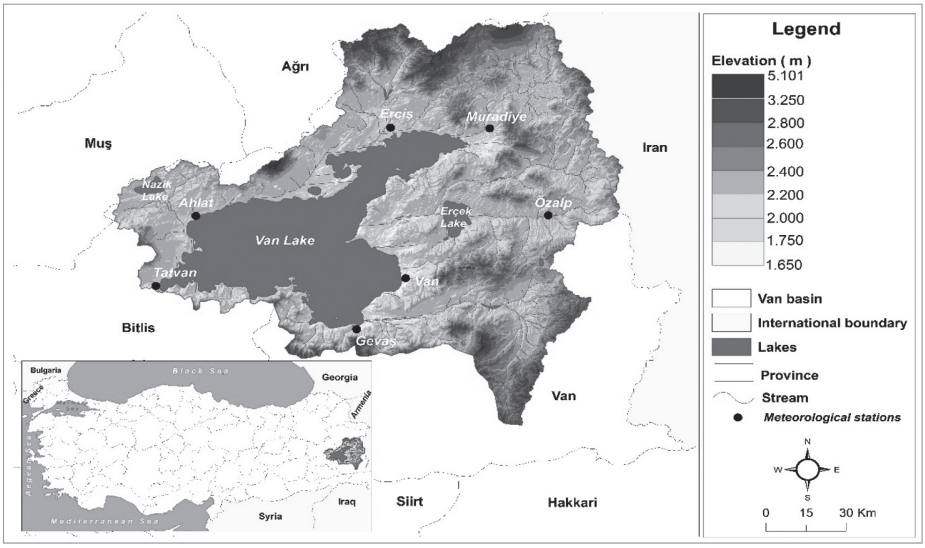
The endorheic basin of Lake Van, located in the Eastern Anatolia region, is taken into consideration within the scope of the study. The purpose of the research is to determine the direction and size the trends of average annual temperature values from 1964 to 2017. The findings of the present study have been compared with some other studies found in the literature

Information about temperature and precipitation, which are the main elements of our climate on our planet, is of great importance in determining the characteristics of global climate variations. The parameters vary greatly on both spatial and temporal scale. Trends in these two parameters provide important clues for understanding the general characteristics of the climate. Therefore, a large number of research studies showing trend analysis of these two parameters on climate change has been conducted in recent years (Turkes, 1996; Tayanc et u, 1997; Kadioglu, 1997; Lazaro et u.S., 2001; Turkes et al., 2002; Tosic and Ukasevic, 2005; Turkes et al., 2008; Karabulut and Cosun, 2009, Coskun, 2011, Addisu, et. al. 2015, Asfaw et al., 2017).

## 2.RESEARCH AREA

The selected research area of Lake Van is located in the Eastern Anatolia region of Turkey. It is the second largest endorheic basin in Turkey after the closed basin of Tuz lake (Salt Lake). The basin is generally seen to have a dish-shaped appearance. The area is surrounded by Van East mountains in the east, Southeast Taurus in the south, Nemrut and Suphan in the west and Aladaglar and Tendurek volcanic mountains to the north (Map 1).




**Map 1:** Meteorology Stations in the Research Area of Van Lake Closed Basin.

## 3. MATERIAL AND METHOD

### 3.1. Mann-Kendall Test

Mann-Kendall Test is one of the statistical methods used to determine the degree and direction of the relationship between variables of interest, regardless of whether the existing variables are dependent or independent, and to show the relationship and trend direction between them. The most important part of this test is that it is easy to apply, and the data is based on successive order of rows. If there is a deficiency in the data, it is not required to allow this deficiency to comply with a certain distribution of the data in this test method.

The Mann-Kendall Test is a method used to determine the direction and severity of trends on the basis of many years of data measured in the fields of hydrology and climatology and is recommended by the World Meteorological Organization. The test is applied to an xi dataset that ranges up to i = 1,…, n-1 and to an xj dataset ranging up to j = i + 1,…, n. Thus, each ranked number xi is used as a reference point and compared to the other sorted data set xj as given in below (Kendall, 1975; Turkes, 1996).

$$(x_j\text{-}x_i) = \begin{cases} 1 & ; \quad x_j > x_i \\ 0 & ; \quad x_j = x_i \\ -1 & ; \quad x_j < x_i \end{cases}$$

When the test is to be applied, pairs of xi, xj in series x1, x2,…, xn are divided into two groups. If the number of pairs xi> xj for ij is denoted by M, the Mann-Kendall test statistic (S) is calculated by the equation given in the Equation (Ozfidaner, 2007).

S= P-M

When S value is n≥8, it shows approximately normal distribution with the mean and variance given. The data length of the equation in n years. If n≥30, the z test approaches the t-test. The test statistic S with a normal distribution and zero mean Var (S) is calculated as in the Equation (Gumus ve Yenigun, 2006).

$$Var(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{p} t_i(t_i-1)(2t_i+5)}{18}$$

In the formula, n indicates the number of data, the number of connected groups in the p dataset, the value of ti represents the number of equal observations in a series of length i. The term equation is used only when there are equal observations

in the data. For example, in time measurements {23, 24, 29, 6, 29, 24, 24, 29, 23}, p = 3 has the bound group. For this, t1 = 2, the value related to 23, t2 = 3, the value related to 24, t3 = 3, the value connected to 29. The standardized Mann-Kendall Test statistic Z can be calculated as given in Equation (7) and there is no going in the series under the assumption of null hypothesis (H0), the standard normal distribution with a mean of 0 and a variance of 1 is shown(Bulut at al. 2006).

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

If the normal distribution of the calculated Z absolute value corresponding to the chosen α significance level is less than Zα / 2, the zero hypothesis is accepted, there is no trend in the time series examined, there is a trend if Zα / 2 is greater, and if S value is positive (+), increasing negative (-) concludes that there is a decreasing trend.

### 3.2. Spearman's Rho Test

It is a test method used to show whether there is a relationship (correlation) in two observation datasets. It is a fast and useful test for determining trends. has The rank statistics of Rxi is determined by sorting the data from small to large, and vice versa. The vector of observation series X = (x1, x2, ……, xn); according to the H0 hypothesis defined by the bidirectional test, xi (i = 1, 2, 3,… ..., n) values are probability distributions and according to H1 hypothesis, xi (i = 1, 2, 3, ……, n) values increases or decreases over time. Spearman's Rho Test statistic (rs) is calculated as shown in the equation (Turkes, 2013).

$$r_s = 1 - 6\frac{\sum_{i=1}^{n}(R\chi_i - i)^2)}{n(n^2-1)}$$

If there are two observation values of the same value, the average should be used. For example, if there are 3 observations with the same observation value, 3 observations with the observation values rankings 6, 7, 8, (6 + 7 + 8 = 21) and 7 values obtained from the 3 observation sections of the number 21 are accepted as the order of these 3 observations. The sequence of the next observation value is 9, so that the observation values are sorted.

Normal distribution tables are used since the rs distribution for n> 30 will approach the normal. For this, the test statistic (Z) of rs is calculated as shown in the equation.

$$Z = r_s\sqrt{n-1}$$

If the Z value is greater than the Zα / 2 value determined from the standard normal distribution tables at the level of α significance, the H0 hypothesis is rejected and a certain trend is reached (Gumus, 2006).

## 4. FINDINGS

### 4. 1. Trend Analysis of Average Temperature Data of Van Lake Closed Basin

Trend analysis was performed after determining the suitability of the data by using various statistical methods to reveal the direction and size of the trends in the average temperature parameters covering the years 1964-2017 of Van Lake closed basin. In order to obtain more accurate results from trend analysis results, it is considered that stations have at least 30 years of uninterrupted data set.

Among the most preferred non-parametric methods in recent studies, Mann-Kendall and Spearman's Rho Trend tests are the leading ones. In the Rho test analysis results of Mann-Kendall and Spearman, there is no trend when Z critical value is within the confidence interval of + -1,96, whereas it is observed that there is a trend when it goes above or below this value.

Data covering the years 1964-2017 in order to determine the trends in the average temperature parameters of the stations in Van Lake Closed Basin are presented in Table 1 by applying tests of Mann-Kendall and Spearman.

The examination of average temperature findings of the stations in the basin during the period of 1964-1917 revealed that on a seasonal basis, there were positive trends in Van-Region, Muradiye, Ozalp and Tatvan stations in all the four seasons, while no trends were found in the remaining stations. Strong annual positive trends were found at Van-Region, Muradiye, Ozalp and Tatvan stations just like seasonal trends (Table 1).

**Table 1: Mann-Kendall and Spearman Rho Test Analysis Results of Van Lake Closed Basin Average Temperature Data**

| **Method** | **Mann-Kendall and Spearman Rho's** | | | | |
|---|---|---|---|---|---|
| **Period** | **Spring** | **Summer** | **Autumn** | **Winter** | **Yearly** |
| Van-Bölge | **4,25** | **5,21** | **4,20** | **4,38** | **5,33** |
| Ercis | 1,48 | -0,22 | 1,73 | 1,19 | 0,71 |
| Gevas | 1,90 | -0,31 | 0,11 | 1,90 | 1,11 |
| Muradiye | **3,34** | **3,83** | **2,33** | **3,15** | **4,74** |
| Ozalp | **2,45** | **3,45** | **2,25** | **3,70** | **3,76** |
| Ahlat | 1,28 | 0,87 | -1,15 | 0,43 | -0,22 |
| Tatvan | **2,10** | **4,16** | **2,22** | **2,7 0** | **4,69** |

The trend directions of the average temperatures of the stations in the basin, as seen in Figure 1, show that there are strong positive trends in Van-Region, Muradiye, Ozalp and Tatvan stations and are distributed according to the trend values in the table.

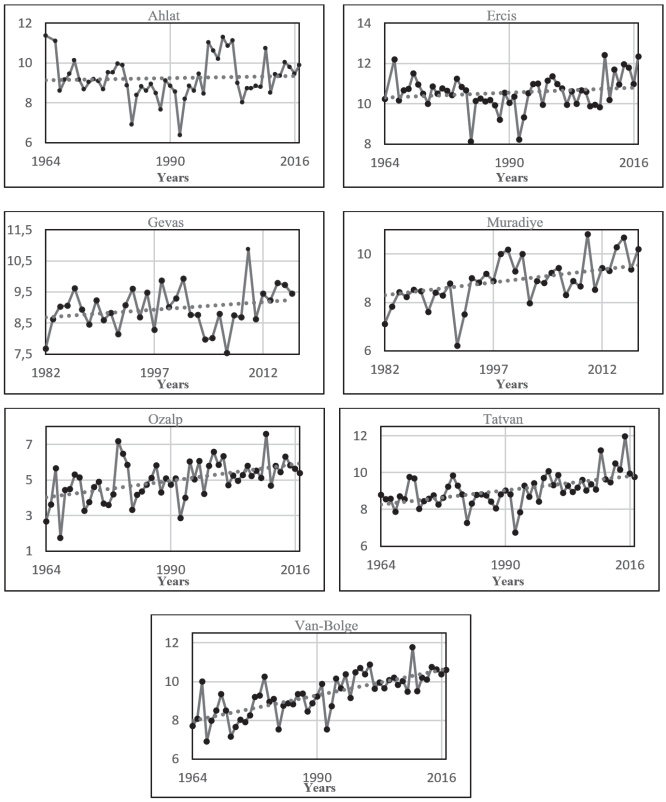



**Figure 1.** Trends of Average Temperatures of Stations in Van Lake Closed Basin

## 5. DISCUSSION AND CONCLUSION

The study area located in the east of Turkey, is an endorheic basin in hydrographic sense. Lake Van is Turkey's largest lake and also forms the second largest endorheic basin. As it is known, the reactions of endorheic basins to climate changes are more noticeable than open basins. This study is an example of from Turkey, a country of middle latitude close to the tropics, whether it is affected by climate change or not.

Reference periods in climate monitoring and climate change studies, using climate normals; It makes it easier to make global, national and regional evaluations as well as integrating past and future studies (Demircan, Arabaci, Boluk,

Akçakaya, Ekici, 2013). According to the findings of 7 stations in the closed basin, annual and seasonal average temperature data were examined in the 53-year period between 1964-2017, Table 2.

**Table 2: Average temperature and seasonal average temperature trend analysis results of the studied stations.**

| **Method** | **Mann-Kendall ve Spearman Rho's** | | | | |
|---|---|---|---|---|---|
| **Period** | **Spring** | **Summer** | **Autumn** | **Winter** | **Yearly** |
| Van-Region | ▲ | ▲ | ▲ | ▲ | ▲ |
| Ercis | ● | ▼ | ● | ● | ● |
| Gevas | ● | ▼ | ● | ● | ● |
| Muradiye | ▲ | ▲ | ▲ | ▲ | ▲ |
| Ozalp | ▲ | ▲ | ▲ | ▲ | ▲ |
| Ahlat | ● | ● | ▼ | ● | ▼ |
| Tatvan | ▲ | ▲ | ▲ | ▲ | ▲ |

As a result of the findings, it has been observed that there is a statistically significant increase in annual temperatures at Van-Region, Muradiye, Ozalp and Tatvan stations. The presence of negative trends at Ahlat station and positive trends at Ercis and Gevas stations are not statistically significant. Demir et al., (2008), in his work on whole Turkey in general, determined that the maximum and minimum temperatures tend to increase. They also emphasized that the warming tendencies were statistically significant in the Mediterranean, South Eastern Anatolia and southern parts of Eastern Anatolia.

On examination of seasonal values, it is seen that there are strong positive trends in Van-Region, Muradiye, Ozalp, while Ahlat station in the spring. The positive trends seen in Ercis, Gevas and Ahlat stations do not express statistical significance.

In the summer, strong positive trends were detected in Van-Region, Muradiye, Ozalp and Tatvan stations. However, although negative trends are observed at Ercis and Gevas stations, these trends do not show statistical significance.

In the autumn season, Van-Region, Muradiye, Ozalp and Tatvan stations have statistically positive trends, while Ahlat station has a negative trend, but it does not show statistical significance.

Van-Region, Muradiye, Ozalp and Tatvan stations have significant positive trends, while the increases in the remaining other stations do not show any significance.

Across Turkey, average temperatures tend to rise globally, like average surface temperatures. Likewise, significant positive trends are observed in Van-Region, Muradiye, Ozalp and Tatvan stations in the study area. Temperature increases at Ercis, Gevas and Ahlat stations are not meaningful.

Some of previous studies have observed an increase in the average air temperature in Turkey which is more obvious in winter and spring seasons showing start of a warming trend (Turkes et al., 2002a-b; Turkes et al., 2004; Turkes, 2005). Similar upward trends are observed in the Van Lake basin. However, various reasons such as the fact that the meteorological stations remain in the city, and the difference in extent of urbanization in the settlements where the stations are installed, may have been influential in the fact that these increases are not prevailed in whole basin. Annual and seasonal average temperature increase trends in the basin; informs that evaporation will increase, falling at the level of Lake Van and withdrawal due to climate along the coastline. It is also recommended to study the trends of precipitation and evaporation in future studies.

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