THE CORRELATION BETWEEN TEMPERATURE AND PRESSURE DATA IN TURKEY

Cercis İKİEL

Sakarya University, Faculty of Science and Art, Department of Geography, Esentepe, Sakarya, e-posta: cikiel@sakarya.edu.tr

Beyza USTAOGLU

Istanbul Technical University, Eurasia Institute of Earth Science,, Maslak, Istanbul, e-posta: beyza.ustaoglu@itu.edu.tr

Abstract

The distribution of the pressure in the earth surface is not equal in every part of the earth due to gravity, height, thermal and dynamic reasons. As well as the effect of the gravity force, in theory, the decrease in sea surface pressure and the amount of decrease in pressure while the height increases should have been the same in everywhere. However the temperature differences and the weather events in the troposphere cause that the weather gets warmer and becomes sparse in some places and gets cooler and becomes dense thus leads to change in pressure depending on the temperature. Based on aforementioned facts, in accordance with the hypothesis that the increase in temperature leads to decrease in pressure and the decrease in temperature leads to increase in pressure, in this study, the relation between the temperature and pressure in the climatic conditions of Turkey are tested by using statistical methods. For that purpose, homogeneity test has been applied to the average temperature and pressure data in months for 31 years, which covers the years 1975-2005, gathered from the meteorology stations of 81 cities in Turkey. Secondly, in order to determine the relation between two variables better as well as the average values, the amplitude values of temperature and pressure have been calculated. As a third step, since the units of the variables are different from each other, in order to establish a healthier relation, both the temperature and the pressure values have been released from units by standardizing. Lastly, in order to determine this relationship, the correlation coefficient method that inspects and scales the together change of two variables and after that cluster analysis method which classifies this relation as variance based by calculating the euclid distance between the data. According to the results obtained from these data, the negative relation between the temperature and pressure has been verified strongly and the emerging results have been grouped seasonally and annually with tables, graphics, and figures.

Key Words: *Temperature, Pressure, Correlation Coefficient Method, Cluster Analysis Method, Turkey.*

Introduction

The layer covering the earth, in which the weather events occur, is defined as atmosphere. The atmosphere consists of different density of gases. The effect of these gases on the surface is called air pressure. However, the pressure of the atmosphere on the earth is not equal in every part of the earth. The gravity, height, thermal (temperature, the arrival angle of sunbeam) and dynamic factors (the earth revolving around its own axis) affects the distribution of the pressure on the earth surface. Due to the gravity force, the heavier gases in the atmosphere remain in lower layers while the lighter ones remain in upper layers. As you go higher in the air, the temperature changes and depending on this also the atmosphere density changes. When the temperature increases in any place, the vibration of the air molecules also increases and they move away from each other. The effect of the expanded and lightened air mass on the earth decreases and low-pressure areas are formed. By temperature decrease, the air mass becomes denser, heavier and it is pressed by descending. The effect of the descending air mass increases and high pressure areas are formed depending on the temperature (Erol 1999). Temperature increase leads to pressure decrease and the decrease in temperature leads to pressure increase. As in accordance with the hypothesis, in this study; the relation between the temperature and the pressure in the climatic conditions of Turkey are tested by using statistical methods. For that purpose, firstly homogeneity test has been applied to the average temperature and pressure data in months for 31 years, which covers the years 1975-2005 gathered from the meteorology stations of 81 cities in Turkey. Secondly, in order to determine the relation between two variables better as well as the average values, the amplitude values of temperature and pressure have been calculated. As a third step, since the units of the variables are different from each other, in order to establish a healthier relation, both the temperature and the pressure values have been released from units by standardizing. Lastly, in order to determine this relation, firstly the correlation coefficient method that inspects and scales the together change of two variables, and secondly cluster analysis method was used. According to the results obtained by means of these methods, the negative relation between the temperature and pressure has been verified strongly and the emerging results have been grouped seasonal and yearly by using tables, graphics, and figures.

Study Area

In this study, 81 meteorology stations of Turkey have been examined, which is an Eastern Mediterranean Country between 36º-42 º north parallels and 26 º 45 º east meridians [Adana, Adıyaman, Afyon, Ağrı, Aksaray, Amasya, Ankara, Antakya, Antalya, Ardahan, Artvin, Aydın, Balıkesir, Bartın,Batman, Bayburt, Bilecik, Bingöl, Bitlis, Bolu, Burdur, Bursa, Çanakkale, Çankırı, Çorum, Denizli, Diyarbakır, Düzce, Edirne, Elazığ, Erzincan, Erzurum, Eskişehir, Gaziantep, Giresun, Gümüşhane, Hakkari, Iğdır, Isparta, İstanbul, İzmir, K.Maraş, Karabük, Karaman, Kars, Kastamonu, Kayseri, Kilis, Kırıkkale, Kırklareli, Kırşehir, Kocaeli, Konya, Kütahya, Malatya, Manisa, Mardin, Mersin, Muğla, Muş, Nevşehir, Niğde, Ordu, Osmaniye, Rize, Sakarya, Samsun, Siirt, Sinop, Sivas, Ş.Urfa, Şırnak,Tekirdağ, Tokat, Trabzon, Tunceli, Uşak, Van, Yalova, Yozgat, Zoguldak] (Figure 1).

Data and Method

In this study, the data was used that contains the average, maximum and minimum pressure and temperature values in months for 31 years covering the years 1975-2005, obtained from the meteorology stations of 81 cities of Turkey which was selected as the investigation area. Great care has been given in the fact that these data have the same periods and the data have been tested by making a homogeneity analysis. In order to determine the relation between two variables better as well as the average values of the temperature and pressure, the "amplitude values"(1) of temperature and pressure have been calculated. In first equation (1), Z_{max} is the standardized maximum value of the variables; Z_{min} is the standardized minimum value of the variables. Since the temperature and pressure are the data having different units from each other (ºC/mb), in order to establish the relation between them healthier with both methods, the values of both data have been released from units by standardizing (İkiel 2005) (2). In this equation (2), Z_{it} is the traditional standardization equation, x_{it} for the station value in year t, $\bar{x}i$ is the average value of the time series, σ_i is the standard deviation of the time series. Since the aim in this study is to determine the relation between two variables digitally and to scale them by locations, the "correlation coefficient method" has been used firstly as a method. As the second method, the cluster analysis method has been used that is not expressed with a certain digital value but the basis of which depends on the variance analysis, classifies data according to their euclidean distances and variances by using classification method. After that, the results of the two methods have been analyzed by being mapped through the program Arc GIS 9.

The correlation coefficient method is a method which inspects the together change of two variables and scales them between +1 and -1 (3).

$$Z_{(max)} - Z_{(min)} \qquad (1)$$

$$Z = \frac{(x_i - \bar{x}_k)}{x_k \sigma} \qquad (2)$$

$$r = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \sum (y-\bar{y})^2}} \qquad (3)$$

The forces of the correlation coefficient classified in this study are;

0.0 /-0.25 very weak relation

-0.25/-0.50 weak relation

-0.50/-0.75 medium relation

-0.75 /-1.00 strong relation

The data obtained in accordance with the amplitude and average values were grouped by considering the correlation coefficient scale and the results of the ARC GIS 9 program have been analyzed in order to see the location distribution of this relation according to correlation coefficient. Furthermore, by considering the amplitude values, in order to see the regional coherence, 3 sample cities have been selected from every region, which has weak (-0.25/-0.50), medium (-0.50/-0.75) and strong (-0.75 /-1.00) correlation relation and their tables and graphics have been formed. Besides the correlation coefficient technique, also the cluster analysis method has been applied in order to determine the relation between the temperature and the pressure and to group the existent relation. Cluster analysis method is a technique aims to form clusters which are the most proximate and smilar ones among the values constitute a data set. There are five critical steps: the choice of variables, decision on standardization, the choice of similarity metrics, selection of methods, the number of clusters, and test of stability (validation). For that purpose, firstly the distance metrics and linkage functions (wards methods) are used. The distance between the two data is calculated by using the euclidean distance method used in calculation of the spatial distance between the data (Johnson R, Wichern D 2007) (4).

$$d_{ij} = \left[\sum_{k=1}^{p} (x_{ik} - x_{jk})^2 \right]^{1/2}$$

(4)

In this equation, d_{ij} is the distance between two data consist of the values of p variables x_1, x_2, $x_3 \ldots x_n$ for n object. x_{ik} belonging to the first variable, x_{jk} belonging to the second variable from k to p. For example the distance two points: A=(3,5) B=(7,9) equals to $[(3-7)^2+(5-9)^2]$. The operation has been calculated between the values of each city and the values of the other cities, which forms the data set by applying both the temperature and the pressure data. By this way, a matrix is formed that includes the distance values regarding the data on the both temperatures and pressures between each city and the other cities.

After the distance values of each city has been calculated, groups with the lowest variance/covariance are formed within the data set. For that purpose, the Wards hierarchical cluster analysis method, that is the most comprehensive and valid method among the climate studies, has been used (Ünal et all 2003). The idea has much in common with analysis of variance (ANOVA). In this method, it is aimed to form a cluster has the lowest variance, by enabling the groups to be clustered, which include the closest distances of one or more variables in a data set. By this way, each group includes the values with the lowest variance in itself, they are the groups including the similar proximities within them and they are separated from the other groups by considering this scale. The linkage function specifying the distance between two clusters is computed as the increase in the "error sum of squares" (ESS) after fusing two clusters into a single cluster. Ward's Method seeks to choose the successive clustering steps so as to minimize the increase in ESS at each step.

The function operated for applying the Wards method (5);

First for a given cluster k, let ESS $_k$ be the sum of the squared deviations of every item in the cluster from the cluster mean. If there are currently K clusters, define ESS as the sum of the ESS_k or ESS= $ESS_1+ESS_2+.....+ESS_k$. At each step in the analysis the union of every possible pair of clusters is considered, and the two clusters whose combination results in the smallest incerease in ESS are joined. x_i is the variable of the time series, $\bar{x}$ average value of the time series. Initally each cluster consists of a single item and if there are combined in a single group of N items the value of ESS is given by,

$$ESS = \sum_{i=1}^{n} (x_i - \bar{x})^2$$

(5) (Johnson R, Wichern D 2007).

For that purpose, a “dendrogam” was obtained by processing the data in the technical computing program MATLAB 6.5 which includes euclidean distance function and ward hierarchical function of cluster analysis (Demirel 2004). Dendrogam; is illustrated as a tree and its branches, and in Cluster analysis it corresponds to the whole data set and the groups separated by it. In the resulting graphics the vertical axis is represented by the “station numbers” and the horizontal axis is represented by the “ESS” value. The ESS value corresponds to “distance” value in these graphics and represents the inter-cluster similarity/proximity and also the “similarity”/“proximity” in each cluster. The lines drawn in the vertical direction enables us to divide the dendogram into more detailed groups which we would like to form other than the groups created by this dendogram “naturally”. In order to be able to see these clusters better in the spatial sense that consists of the station data which are similar in themselves respectively, the clusters were analyzed in Arc GIS 9 program by being represented in letters. This resulting picture has introduced the spatial distribution of this relation in detail.

Discussion and Results:

In the methods we have applied so far in order to determine the relation between the atmospheric temperature and the pressure by using the annual average and amplitude pressure and temperature values, it has been observed that the both resulting figures are similar to each other but the amplitude values give more coherent results in comparison to the average (Figure 2-3). According to this when we look at the Figure 3 predicated on the amplitude values, it is seen that the northern regions of Thrace Region, eastern regions of Mediterranean Region and Black Sea Region and eastern and southern regions of the Eastern Anatolia Region show weaker relationship throughout year in comparison to the general Turkey. It is seen that in the basis of this distribution, the conditions constituting the climate in the general country depend on the general atmosphere circulation, air masses, front systems, and also the physical geography factors (continental, marine, height). When we look at the general regions of Turkey in terms of regional coherence, it is seen that the most coherent region is the Aegean Region. (Table 2; Graphic 2; Figure 3). According to the average annual amplitude values; Denizli has the strongest relation with (-0.94) while Afyon has the weakest relation with (-0.75) medium degree correlation in Aegean Region (Table 2; Graphic 2). Marmara and Interior Anatolian Regions show a coherent relation inside in comparison to the other regions (Table 3; Graphic 3; Table 6; Graphic 6). The correlation values for Bursa (-0.93), (-0.59), Bilecik (-0.34) in Marmara Region and Niğde (-0.94), Kırıkkale (-0.68) Kışehir (-0.58) in Interior Anatolian Region. If you look at the regions that contains noncoherent members, we see this picture: In Mediterranean Region, Antalya (-0.92) is coherent to Adana (-0.50) while it is not coherent to to Mersin (0.48) (Table 1; Graphic 1); In the Black Sea Region, Bayburt (-0.96) is coherent to Ordu (-0.69) while it is not coherent to Rize (0.36) (Table: 5; Graphic: 5); In the Eastern Anatolian Region, Erzincan (-0.98) is coherent to Kars (-0.58) while it is not coherent to Iğdır (0.21) (Table 4; Graphic 4); In Southeastern Anatolian Region, Kilis (-0.98) is coherent to Diyarbakır (-0.68 while it is not coherent to Batman (0.0) (Table: 7; Graphic: 7). When we look at the results we have obtained by using the cluster analysis we see a condition similar to the results we obtained by using the correlation analysis. When we particularly map the results of these two methods in order to observe them, it is observed that the annual average and amplitude pressure and temperature values obtained in both methods are clustered in the same regions (Figure 2-3; Figure 4-5).

This situation can be explained on the basis of the logic of the cluster analysis method. After calculating the euclidean distance of the data standardized in the cluster analysis, the cities with the lowest co-variance and therefore the closest cities are collected in a group. Therefore, since these cities act together statistically, the relation between them in other words the correlation coefficient will be very high. The result is that, although the methods we use in order to determine this relation are different from each other, they introduce similar results. In the correlation coefficient method, the relationship between the variables are detected; and in the cluster analysis method both the relation between the variables are detected and this relation has been classified as based on variance structure in accordance with the wards method. In the correlation coefficient method transaction can be made with no necessity to make the variables without uniting, furthermore the correlation coefficient technique introduces a digital expression about the power of a relation (such as %75). This gives us information about the rightfulness of the introduced hypothesis. The cluster analysis method introduces a very detailed result which will bases on the change within the data set in the classification sense. In this technique the values within the data set are divided into variance based groups by calculating the euclidean distances. The expression method in here only shows the location distribution of this relation. Since this principle is also important in the geography, it is very meaningful for this study to scale the locations, which have excellent relation within and the weaker relation with others.

With the cluster analysis method, when we look at the dendogram which is classified in accordance with the annual amplitude values, we see that Turkey is divided into five regions in terms of atmospheric temperature and pressure relation.

According to general atmosphere circulation, air masses and front systems, the physical geographical factors (continental, marine, height) and the local conditions, the closest and similar cities are clustered (Figure 5). According to this, when we look at the general picture, we can see that the cities represented with A are in majority and when we base on this relation we see that they behave in the same way and that the other cities as in small groups behave similarly in themselves. Furthermore, according to the distance values (5-8), it is seen that each group has similar distance to each other, coherent within and different with the others. When we look at the dendogram, which is classified according to the seasonal amplitude values by using cluster analysis (Figure 6-7-8), it is seen that the covariance between the groups in winter and spring, in other words the distances of the groups in themselves and between each other, are higher when compared to the ones in summer season. In other words, it is seen that the cities forming the group and the cities in the other groups are separated from each other in certain differences. This situation is the proof of the fact that atmospheric activities are much in winter and spring when compared to summer season, and going and coming of various air masses and transition of cyclones are experienced (Bartzokas et all 2006, Koçman 1993, Kostopoulou and Jones 2007). Since the effect of the continental condition disappears in summer, similar climate conditions are experienced in the general country and the effect of Mediterranean season is felt more common (İkiel 1997). It it is seen that in winter and spring seasons the representation power of each group is rather dominant and they behave relatively more independent when we look at the distance between them (Figure 6-8). In summer season, it is seen that the northern regions of Thrace Region and Interior Anatolian Region, eastern regions of East Anatolia Region and the northern and southern regions of Southeastern Anatolia Regions have a more clear difference in comparison to the other regions according to the distance (covariance based) (Figure 7). However, the general picture shows that the groups close to each other seasonally and annually are formed. This is the proof of the fact that the physical geographical factors (continental, marine, height) are effective on Turkey as much as the general atmosphere circulation, air masses and front systems (İkiel 1998).

It has been planned that the places where the pressure and temperature relation is powerful and weak according to the correlation method and the dynamic factors such as the physical geographical factors (continental, marine, height) which are effective on the regions grouped as euclidean distance and variance based with the cluster analysis method and the effective air masses and front systems will be examined and analyzed in the further stages within the scope of the project.

References:

Bartzokas A., Metaxas D.A., Ganas I.S. (2006) Spatial and temporal sea-surface temperature, covariances in the Mediterranean. International Journal of Climatology, V:14, Issue:2, pp.201-213.

Demirel C. (2004) Cluster Analysis of Streamflow Data Over the Turkey. M.Sc.Thesis, IstanbulTechnical University, Instıtute of Science and Technology, İstanbul.

Erol O. (1999) Genel Klimatoloji. Çantay Kitabevi, İstanbul.

İkiel C.(1997) Muğla ve Çevresinin İklimi, Fırat Üniversitesi Sosyal Bilimler Enstitüsü Coğrafya Anabilim Dalı, (Basılmamış Doktora Tezi), Elazığ.

İkiel C. (1998) Türkiye Fiziki Coğrafyasına Genel Bir Bakış. Yeni Türkiye Dergisi. Sayı: 4, Sf: 104-115, Ankara.

İkiel C. (2005) Rainfall Regime Regions in Turkey (A Statistical Climate Study). International Symposium on Forest Impact on Hydrological Process and Soil Erosion, October 2005, Yundola Bulgaria.

Johnson R., Wichern D. (2007) Applied Multivariate Statistical Analysis, 6th Edition pp. 669-693.

Koçman A. (1993) Türkiye İklimi, Ege Ünv. Edebiyat Fak. Yayını, No:72, İzmir

Kostopoulou E., Jones P.D. (2007) " Comprehensive analysis of the climate variability in the eastern Mediterranean. Part II: relationships between atmospheric circulation patterns and surface climatic elements International Journal of Climatology,

Ünal Y., Kindap T. ,Karaca M. (2003). Redefining the climate zones of Turkey using cluster analysis. International Journal of Climatology, 23. 1045–1055.

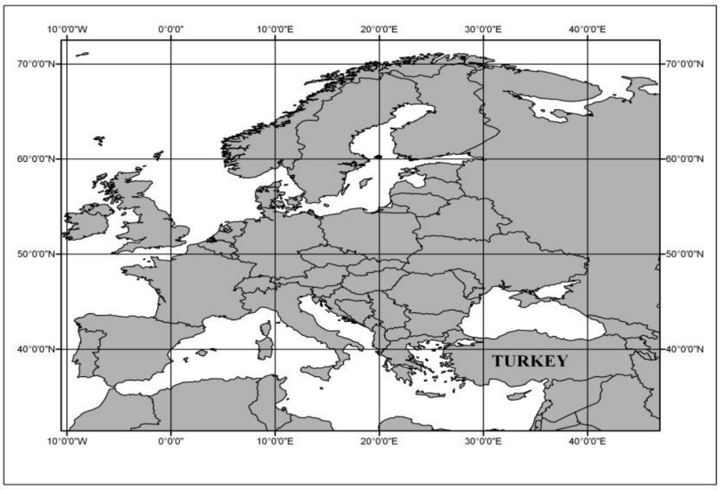


Figure 1: The location map of Turkey

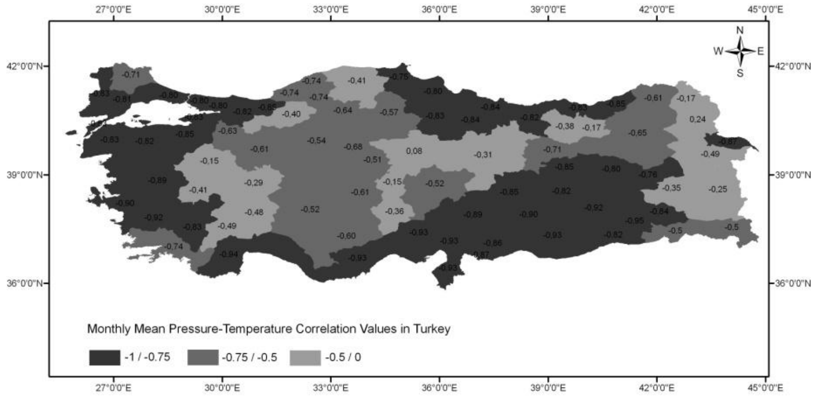


Figure 2: Monthly Mean Pressure-Temperature Correlation Values in Turkey.

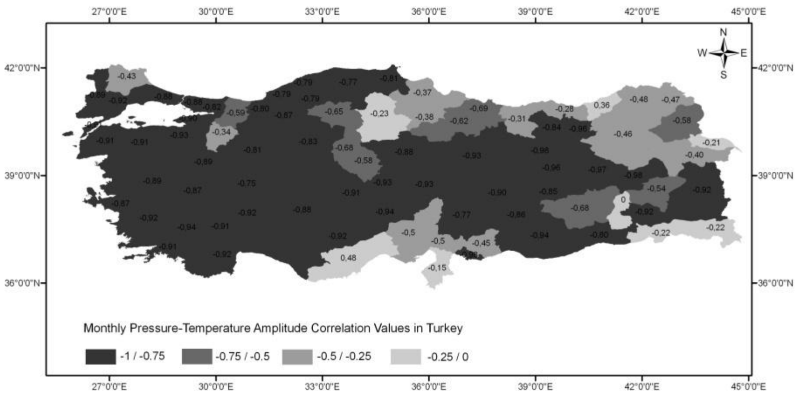
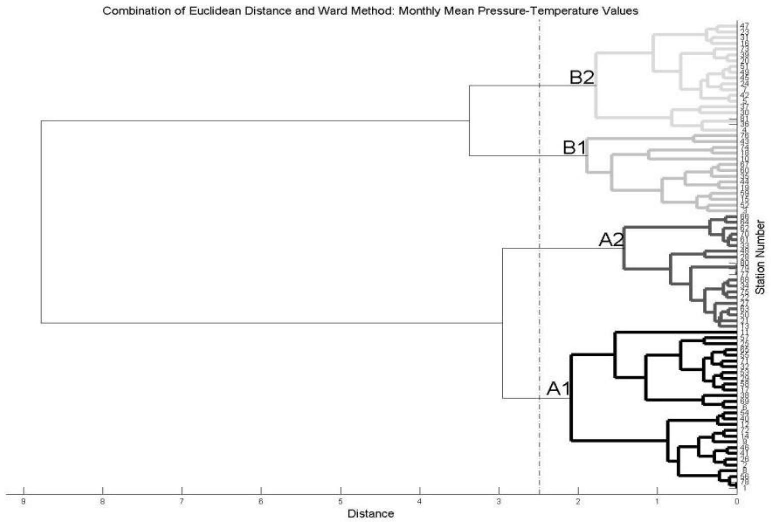


Figure 3: Monthly Pressure-Temperature Amplitude Correlation Values in Turkey.



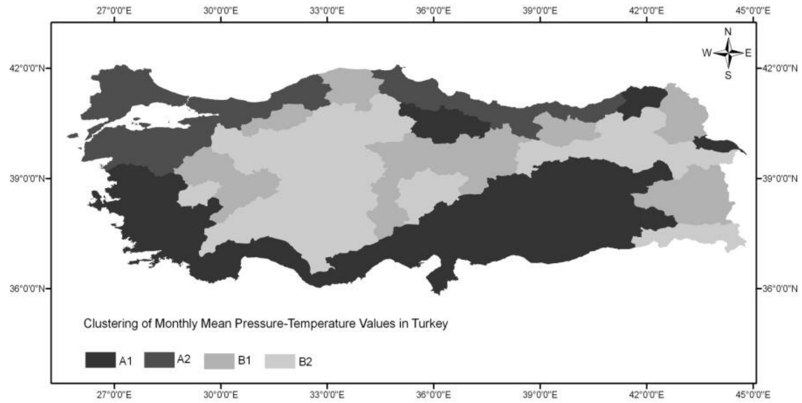


Figure 4: Clustering of Monthly Mean Pressure-Temperature Values in Turkey.

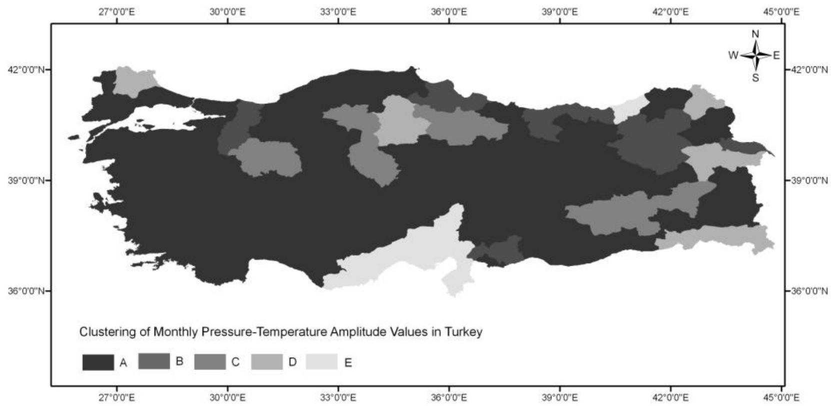


Figure 5: Clustering of Monthly Pressure-Temperature Amplitude Values in Turkey

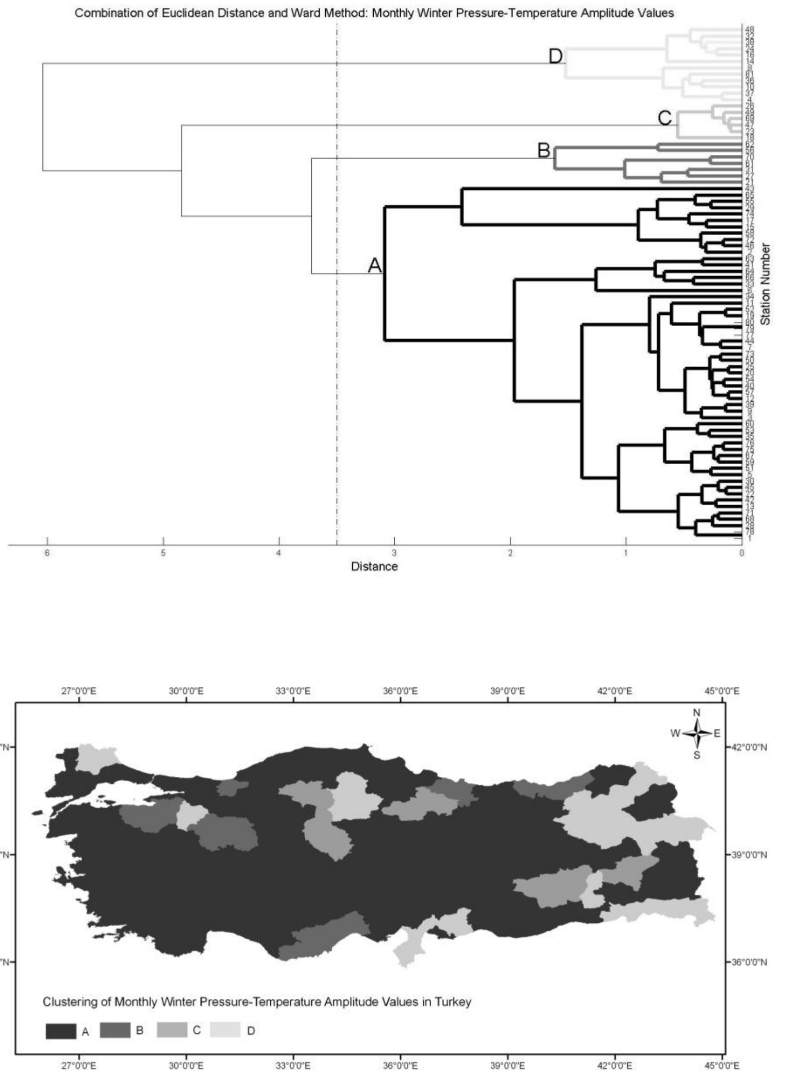


Figure 6: Clustering of Monthly Winter Pressure-Temperature Amplitude Values in Turkey

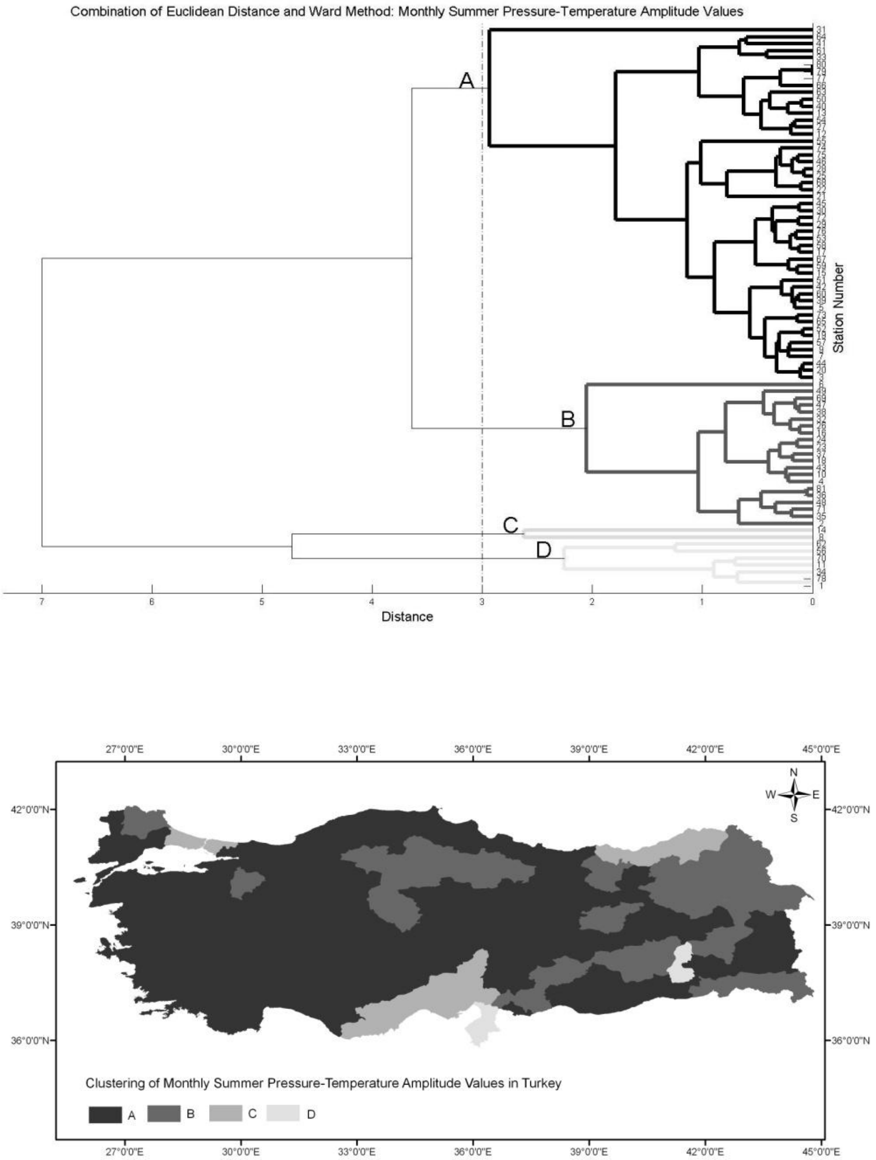
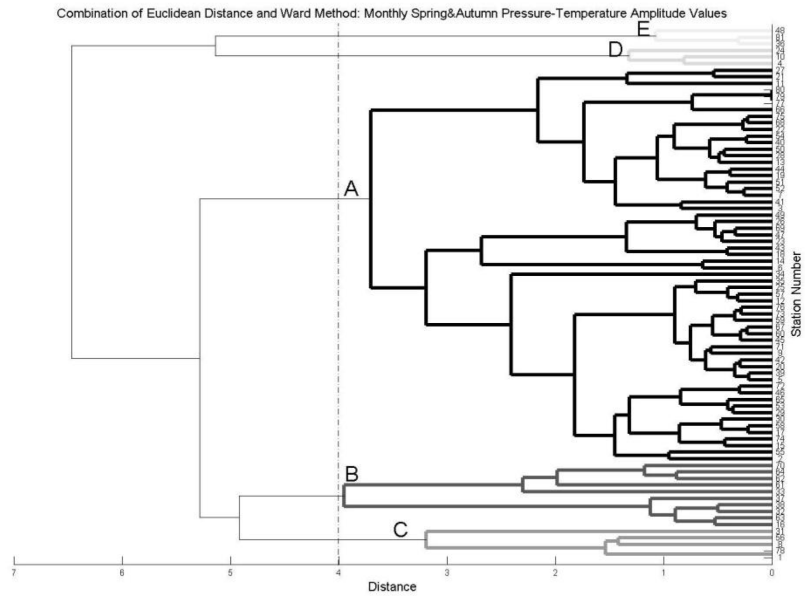


Figure 7: Clustering of Monthly Summer Pressure-Temperature Amplitude Values in Turkey

Table 1: The cities with strong, medium, weak amplitude correlation values in Mediterranean Region

Station	**Data**	**XII**	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**Avg.**	**σ**
Antalya	P_Amp.	34,0	46,1	35,6	37,3	28,4	22,1	18,0	16,8	12,9	18,4	23,2	28,4	26,8	10,0
	T_Amp.	9,5	9,4	9,6	10,5	10,8	11,4	12,3	12,3	12,5	12,7	12,4	11,0	11,2	1,3
	Z_P_Amp.	0,7	1,9	0,9	1,1	0,2	-0,5	-0,9	-1,0	-1,4	-0,8	-0,4	0,2		
	Z_T_Amp.	-1,4	-1,4	-1,3	-0,6	-0,3	0,2	0,9	0,9	1,0	1,2	1,0	-0,2		
Adana	P_Amp.	35,3	40,2	36,2	37,1	28,5	22,4	19,2	16,9	14,7	17,5	22,3	30,7	26,8	9,0
	T_Amp.	9,6	9,5	10,2	11,1	11,3	12,0	11,6	10,2	10,6	12,4	13,0	11,5	11,1	1,1
	Z_P_Amp.	0,9	1,5	1,0	1,1	0,2	-0,5	-0,8	-1,1	-1,3	-1,0	-0,5	0,4		
	Z_T_Amp.	-1,4	-1,4	-0,8	0,0	0,2	0,8	0,5	-0,8	-0,4	1,2	1,7	0,4		
Mersin	P_Amp.	33,2	40,0	37,8	37,7	30,2	23,9	18,9	16,1	13,3	18,9	22,1	30,4	26,9	9,2
	T_Amp.	7,9	7,9	8,2	8,3	7,9	7,4	6,5	6,1	6,6	8,3	9,6	9,2	7,8	1,0
	Z_P_Amp.	0,7	1,4	1,2	1,2	0,4	-0,3	-0,9	-1,2	-1,5	-0,9	-0,5	0,4		
	Z_T_Amp.	0,1	0,1	0,4	0,5	0,1	-0,4	-1,3	-1,6	-1,2	0,5	1,7	1,3		



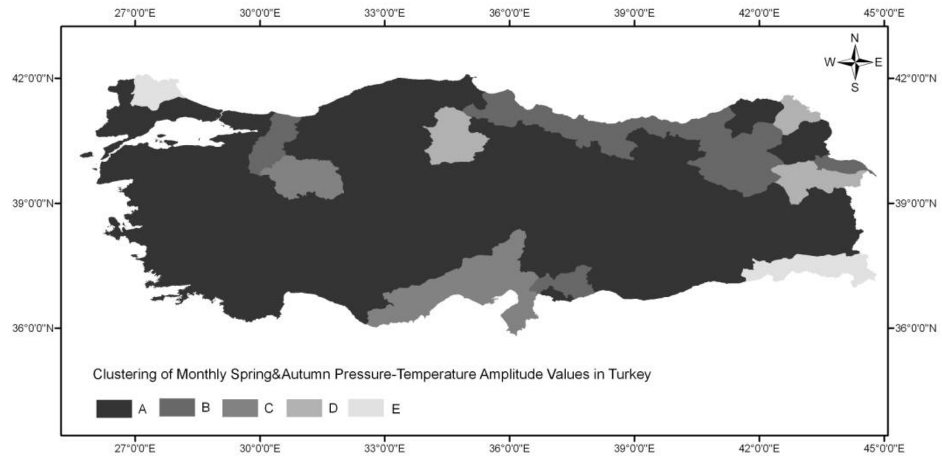


Figure8: Clustering of Monthly Spring&Autumn Pressure-Temperature Amplitude Values in Turk.