

**EFFECTS of MARITIME and CONTINENTAL CLIMATES
on VEGETATION and SEASONAL PERIODS: The CASE of
NORTHEASTERN TURKEY**

*Denizellik ile Karasallığın Vejetasyon ve Mevsim Süreleri Üzerine
Etkileri; Türkiye'nin Kuzeydoğusu Örneği*

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ABSTRACT

The study field is located in the boundaries of two regions in the northeast of Turkey. These regions are the Black Sea Region where the maritime climate is dominant and the East Anatolian Region where the continental climate is dominant. The study area includes Trabzon and Rize from the coastal stations, and Erzurum, Kars and Ardahan from the midlands. These stations were torn by Çoruh depression and divided from each other by East Black Sea mountain ranges. Consequently, maritime effect cannot infiltrate into the midlands. Limitation of maritime effect in the coastal region because of high mountain ranges caused climatic features of these stations to be very different from each other. Furthermore, in contrast to the global tendency, the intensity of continentality caused an increase from the north to south. Great differences on climatic season duration and vegetation periods have been determined in the field of study where continental effects increase from north to south and from west to east. While winter season covers five months and summer season extends up to four months in coastal regions of Trabzon and Rize, transition seasons are nearly 45 days. The duration of winter season in inland stations of Erzurum and Kars is nearly eight months and other seasons are nearly 45 days. In Ardahan, where continentality is dominant, summer season is not experienced literally and it is determined that winter season covers a period of nine months and there are transition seasons lasting up to 45 days. The conditions of maritime and continentality have influenced vegetation periods and while plants can show a development in the coast for a long period of the year, the vegetation period in midlands is 100 days shorter with respect to the coast.

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ÖZET

İnceleme alanı Türkiye'nin kuzeydoğusunda, iki bölge sınırları içinde bulunur. Bu bölgeler denizel iklimin hâkim olduğu Karadeniz Bölgesi ile karasal iklimin egemen olduğu Doğu Anadolu Bölgesidir. Çalışmada, kıyı istasyonlardan Trabzon ve Rize, iç kısımda ise Erzurum, Kars ve Ardahan istasyonları ele alınmıştır. Bu istasyonlar Çoruh depresyonu ile yarılmış Doğu Karadeniz sıradağlarıyla birbirinden ayrılmıştır. Bu nedenle denizel etki iç kısma sokulamaz. Denizel etkinin yüksek sıradağlar nedeniyle kıyıda sınırlanması bu istasyonların iklim özelliklerinin de birbirinden çok farklı olmasına neden olmuştur. Hatta karasallığın şiddeti, küresel eğilimin aksine kuzeyden güneye doğru artmasına neden olmuştur. Karasal etkilerin kuzeyden güneye ve batıdan doğuya doğru arttığı inceleme alanında, iklimik mevsim süreleri ve vejetasyon devrelerinde büyük farklılıklar tespit edilmiştir. Kıyıda yer alan Trabzon ve Rize'de kış mevsimi beş aya, yaz mevsimi ise dört aya kadar uzarken geçiş mevsimleri yaklaşık 45 gün kadardır. İç kısımda bulunan Erzurum ve Kars'ta kış mevsiminin süresi yaklaşık sekiz ay kadar iken diğer mevsimler 45 gün kadardır. Karasallığın hâkim olduğu Ardahan'da ise gerçek anlamda yaz mevsimi yaşanmamakta olup dokuz ay süren bir kış mevsimi ile 45 gün süren geçiş mevsimlerinin olduğu tespit edilmiştir. Denizellik ve karasallık durumu vejetasyon devrelerine de yansımış olup kıyıda yılın büyük bir bölümünde bitkiler gelişme gösterebilirken iç kısımda vejetasyon devresi kıyıya göre 100 gün kısalmıştır.

Anahtar Kelimeler: Denizellik, karasallık, iklimik mevsim süreleri, vejetasyon devresi

INTRODUCTION

The study field covers an area on the northeast of Turkey. There are five typical stations in research area situated in the boundaries of coastal region where maritime climate is dominant and midlands where continental climate is dominant. From these stations, Rize and Trabzon are located in the coast and Erzurum, Kars and Ardahan are located in midlands (Figure, 1-2-3). Average height of inland stations from the sea level is 1850 m in

Erzurum, 1768 m in Kars and 1800 m in Ardahan. Coastal stations and midlands stations are divided from each other by bow shaped the East Black Mountain Ranges stretching in the direction of northeast-southwest. The East Black Sea Mountain Ranges are shaped in two parallel mountain ranges divided from each other by Çoruh depression (Figure-2 and Figure-3). The highest peak of these mountain ranges in the coast is Kaçkar Mountain (3932 m). The Yalnızçam Mountain Ranges (3202 m), the Mescit Mountain Ranges (3239 m) and the Allahuekber Mountain Ranges (3120 m) are located in the midlands. Maritime effect cannot infiltrate midlands because of the laying of mountains and elevation. Consequently, duration and effects of continentality increase with the move towards inner regions.

Annual average temperature of Rize, one of the stations located on the coast, is 14.1 °C. The coldest month has extended to February due to the influence of maritime with an average temperature of 6.2 °C, and for the hottest month (August) average temperature is 23.1 °C. Therefore, the amplitude value is 17.1 °C. Annual average temperature for Ardahan, an inner station, is 3.7 °C. With the influence of continentality, the coldest month in there is January with an average temperature of -11.4 °C. The hottest month is August with 16.4 °C. According to this, the amplitude value is 27.8 °C. There is a 10 °C amplitude difference between the coast and inner regions and this situation is important since it the continentality increases by the move from the coast to the inner region.

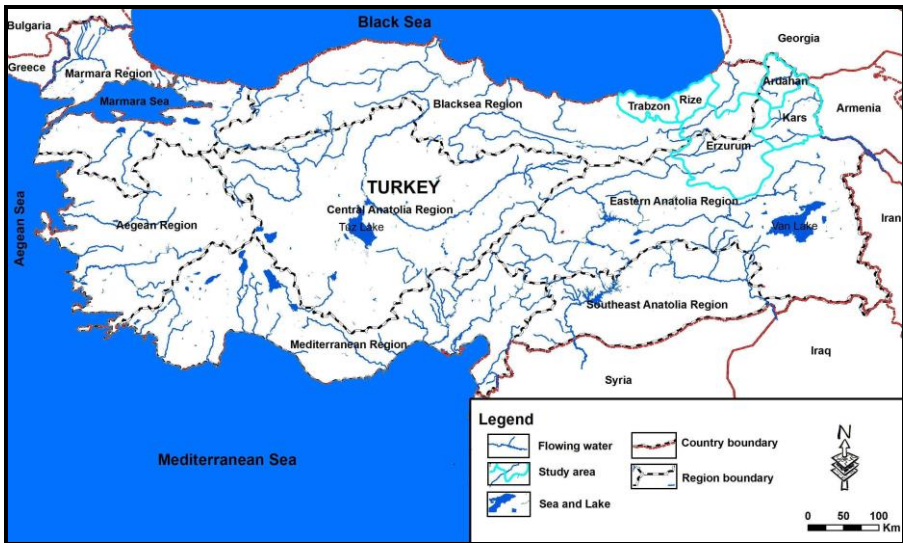


Figure 1. Location map of the study area.

In a study named “The Distribution of the Mean Annual Temperature Range (amplitude) in Turkey and a New Formula on the Degree of Continentality” Sezer (1993) tried to define climatic

differences between the coastal regions and inner regions by presenting the relations between amplitude and continentality and offered a new evaluation formula. According Sezer's continentality formula, which reflects the influence of present continentality on the environment with a great section of 95 %, continentality on the east of Turkey decreases from the south to north in opposition to the "main global tendency". In this decline, continentality degree difference between two parallels is 0.19 %. The influence of maritime climate is stronger in the north coasts of Turkey in general. The first reason for this situation is that Turkey is a peninsula surrounded by water on three sides, the second reason is that the north of Turkey is in mild temperate zone and the south of Turkey is in hot subtropical zone. Whether the transportation of heat through conduction, and in general sense through convection, is at maximum level or not depends on the temperature in water, on land and whether the difference between them is at maximum level or not. These conditions only completely occur in temperate zone. Temperature difference decreases at utmost in subtropical, tropical and especially in equatorial zone (Sezer, 1993). Sezer also noticed that according to the distribution of annual temperature amplitude in Turkey the highest locations in Turkey are the high and inland central regions of Eastern Anatolia and the locations with the lowest values are near the sea with high constant humidity level, high specific heat and low albedo value materials covering vast surfaces. It is also noticed that **while continentality in the east of Turkey increases from the north to the south, it increases from the south to the north in the west confirming to the main global tendency**. According to the Sezer continentality formula, there are three distinct climatic types in Turkey: maritime, maritime-continental transitional and continental climate. According to this classification, while Trabzon and Rize in the coastal Black Sea region belong to **maritime climate type**, Erzurum, Kars and Ardahan in Eastern Anatolian Region are in **continental climate type**. According to this formula, continentality value has been estimated in Trabzon as 16.39 %, in Rize as 16.75%, in Erzurum as 32.76% and in Kars as 38.83%. This shows that there is a difference of 12 % between the coastal and inner regions (Sezer, 1993).

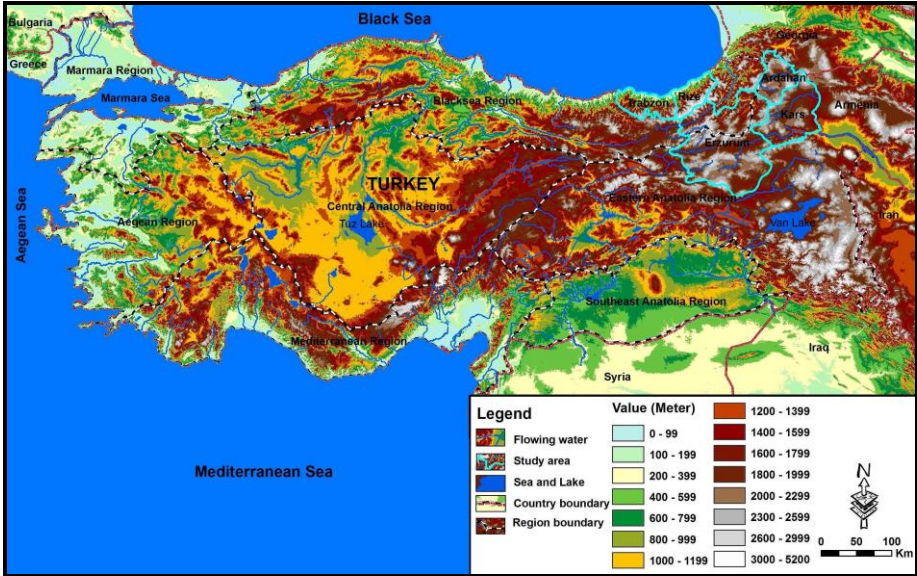


Figure 2. Physical map of Turkey and the study area.

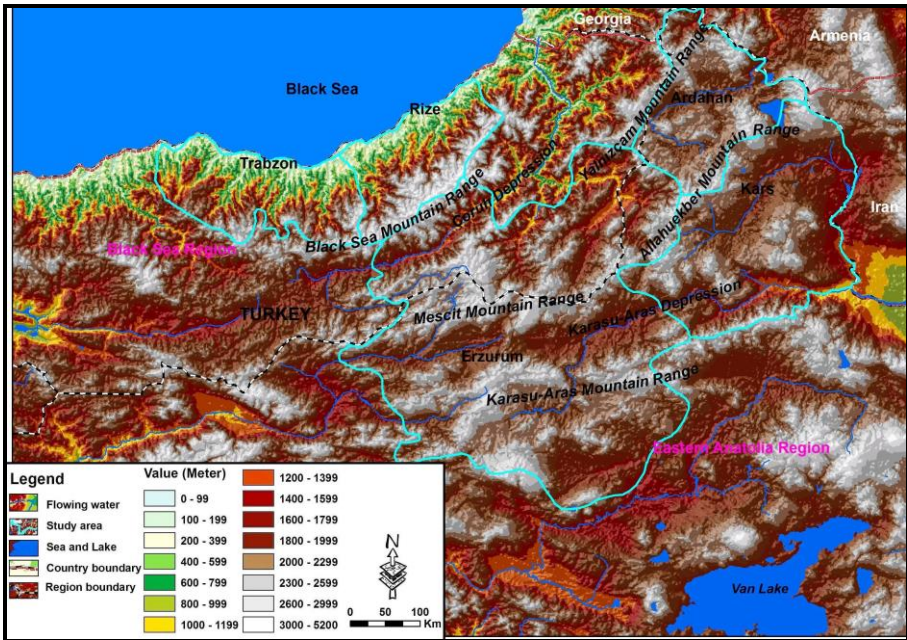


Figure 3. Three dimensional physical map of the study area.

Table 1. Monthly temperature distribution of the study area (Meteorology Service of Turkey) and amplitude values.

Stations	Meteorological Element	M O N T H S												Amplitude (°C)	Annual
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII		
Trabzon	Average Temp. (°C)	7,4	7,0	8,3	12,0	15,8	20,2	23,1	23,2	20,1	16,2	12,3	9,2	16,2	14,6
Rize		6,5	6,2	7,8	11,8	15,9	20,2	22,8	23,1	19,8	15,8	11,4	8,1	16,9	14,1
Erzurum		-9,6	-8,5	-2,8	5,5	10,4	14,9	19,3	19,4	14,3	7,5	0,2	-6,4	29,0	5,4
Kars		-10,2	-8,5	-2,5	5,6	10,0	13,9	17,6	17,8	13,6	7,2	0,2	-6,5	28,0	4,9
Ardahan		-11,4	-10,1	-3,9	4,7	9,2	12,8	16,3	16,4	12,3	6,5	-0,2	-8,1	27,8	3,7

Table 2. Monthly Meteorological Elements of the study area

STATIONS	METEOROLOGICAL ELEMENTS	M O N T H S												Annual
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
RIZE	Areal Precipitation (mm)	211,3	182,2	143,3	92,8	98,6	138,4	136,9	174,9	241,6	314	255,2	249,5	2238,7
	Average number of snowing days	3,0	3,7	1,8	0,2							0,3	1,8	10,7
	Average Number of snow covered days	3,3	4,7	1,8	0,0		0,0					0,2	2,2	12,2
TRABZON	Areal Precipitation (mm)	76,8	64,8	59	59,6	53	54,5	37,1	51,5	74,1	119,3	95,7	85,9	831,3
	Average number of snowing days	3,3	3,9	1,6	0,3	0,0						0,3	1,5	10,8
	Average Number of snow covered days	1,8	3,0	0,8	0,0							0,0	0,8	6,4
ERZURUM	Areal Precipitation (mm)	20,1	25,8	31,9	57,1	71,2	41,7	25,9	15,0	20,3	47,0	32,0	23,1	411,1
	Average number of snowing days	12,4	12,7	13,0	5,5	0,6	0,0			0,1	1,2	6,1	12,2	63,3
	Average Number of snow covered days	27,8	27,1	20,6	3,2	0,2					1,2	7,8	24,4	112,3
KARS	Areal Precipitation (mm)	19,6	22,5	28,4	52,2	78,2	72,2	52,3	40,3	26,6	43,5	26,0	21,7	483,5
	Average number of snowing days	9,3	9,4	9,5	4,6	0,8					1,2	4,6	9,7	49,0
	Average Number of snow covered days	28,9	25,8	19,7	2,6	0,2		0,0			0,9	7,3	22,1	107,5
ARDAHAN	Areal Precipitation (mm)	17,4	22,0	29,6	54,0	83,3	89,3	70,1	54,6	32,4	40,7	29,2	24,3	546,9
	Average number of snowing days	7,5	8,8	8,5	4,5	0,6	0,0			0,1	1,4	5,4	7,8	44,7
	Average Number of snow covered days	30,7	28,2	24,5	5,6	0,3					1,4	10,0	26,3	127,0

1. DATA AND METHODOLOGY

In this study, vegetation periods in Turkey depending on orographic conditions in short ranges have been assessed on the Northeastern Anatolia scale. Daily average, maximum and minimum temperature values have been used as the data. Data period covers 33 years from 1975 to 2008. As the methodology of the study, average temperature values have been constricted between the vegetation period distinction intervals suggested for the Middle Zone. The inspection of distinction criteria on this subject show that researchers take 8 °C as the start of the vegetation period (Atalay, 1975; 1994, Erinç, 1962; 1996, Sungur, 1980; Şahin, 1989; Toroğlu, 2007; Aydınöz, 2010). Thus, the periods below 8 °C are taken as without vegetation period and the periods with values higher than 8 °C make up the vegetation period. The same method signifies that periods with values lower than 12 °C correspond to winter season, the first period of the year with average temperatures of 12-18°C correspond to spring season, average values higher than 18°C correspond to summer and the second part of the

year with 18-12 °C correspond to autumn. These values are accepted in general terms for the middle zone countries. It is not possible to find the suitable values for countries such as Turkey where the climate conditions change in very short distances. Limit values of the graphs have been defined on the figures during their preparation and they have been overlapped with the average temperature values. Suitable locations have been colored with suitable colors and durations of vegetation period, without vegetation period, winter, spring, summer and autumn seasons and changes have been defined. For mapping techniques, geographical information systems have been used. Physical maps for the study area have been produced by using digital database of Turkey.

From the statistical methods, correlation analysis has been made and a strong significance has been found between the increase of continentality degree and the shortening of the duration of spring and autumn seasons. It is also determined that the duration of seasons are more stable in the coastal areas where the maritime effects increase and statistically there is a significant relationship between spring and autumn seasons and maritime. A strong meaningful correlation has been found between maritime and the increase of vegetation period. According to this situation, the increase of maritime stands statistically for the extension of vegetation period.

2. ANALYSIS AND FINDINGS

2.1. Climatic Season Durations and Vegetation Period

According to calendar seasons there are four seasons in a year with definite starting and ending dates. But the climatic season durations (real season) change with respect to the geographical conditions of the field. This situation affects the vegetation period (growing season) of plants directly. For this reason the extension or the briefness of the vegetation periods makes up one of the most important natural factors for the formation of life and economy. Thus, the comparative identification of vegetation periods of maritime and continental stations on the Northeastern Anatolia where the effects of maritime and continentality extended limits has given the following findings.

2.1.1. Coastal Area (Black Sea Region)

Trabzon and Rize are the coastal stations and the annual average temperature for **Trabzon** is 14.6 °C. The coldest month is delayed two months due to maritime effect to February (7.0 °C). The hottest month is August with 23.2 °C. According to this, the amplitude value is 16.2 °C (Table, 1). Total annual precipitation is 831 mm in Trabzon with the highest amount in autumn while there is no great difference among the seasons (Table, 2). Average number of days with snow is only 10. Snow does not

remain on the ground due to maritime effect and the number of snow covered days is lesser than the number of snowing days (6.4 days).

The inspection of **climatic season durations** in Trabzon shows that the winter starts on 9 November and influences the period until 5 April. While the spring season is between 6 April and 28 May, summer covers a period between 29 May and 25 September. Autumn is between 26 September and 8 November (Figure, 4). According to this, winter in Trabzon lasts nearly for 5.5 months. It is striking that while the start of the season closely follows the calendar season, the end of the season is delayed and moves to spring months. The reason for this situation is the two months delay of coldest month to February and thus the prolongation of winter season for nearly 1.5 months. Accordingly the end of winter season extends to the first week of April. Summer season covers a period of 4 months. Because of the prolongation of winter and summer durations, spring and autumn as the transition seasons are short in duration.

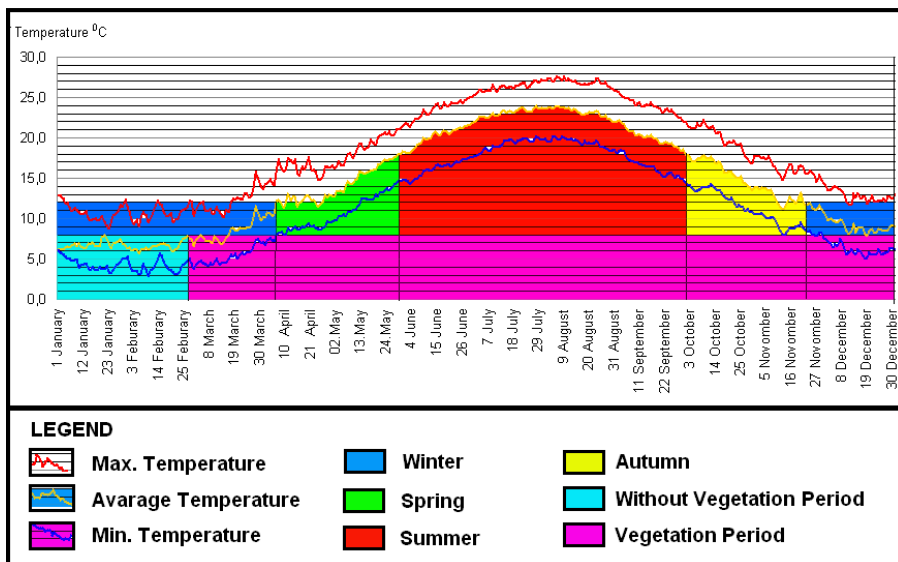


Figure 4. Vegetation and season periods of Trabzon

The inspection of **vegetation period** in Trabzon in the study field shows that it is the station with the longest vegetation period. Plants can grow in the period starting from 16 March and continuing until the end of the year. Without vegetation period is very short and lasts only for 2.5 months (Figure, 4).

Another station situated on the east of Trabzon is **Rize**. Annual temperature value for Rize is 14.1 °C. The coldest month is February with 6.2 °C temperature average and the hottest month is August with 23.1 °C temperate average. Accordingly amplitude value with 16.9 °C is not high (Table, 1). Rize is the highest precipitation receiving station in Turkey with 2238 mm. Precipitation occurs at most in November (314 mm) and in December (255 mm) and continues regularly throughout the year. The amount of precipitation even in the least month (April) is 92 mm. While the number of snowing days is 12, the number of days with snow remaining on the ground is shorter (10 days).

Climatic season durations of Rize show similarities to Trabzon. Winter season starts on 10 November and continues for five months until 10 April. Spring season occurs between 11 April and 26 May and summer covers the period between 27 May and 30 September (Figure-5). Autumn lasts for forty days starting from 1 October to 9 November (Table, 3).

The start of vegetation period is the same with Trabzon, 16 March. But, unlike Trabzon, vegetation period ends on 10 December. Thus, the growth and development of plants in Rize continues for nine months (Figure, 4).

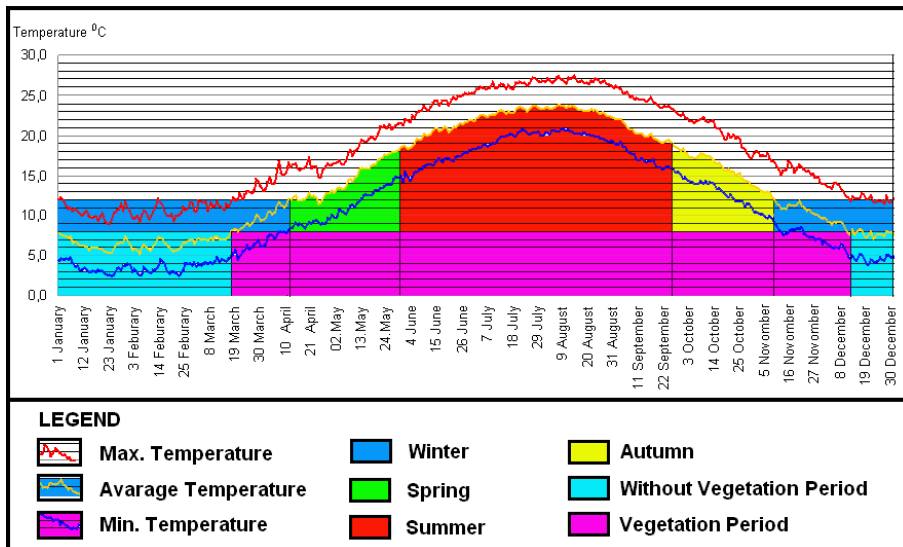


Figure 5. Vegetation and season periods of Rize

2.1.2. Inner Region (Eastern Anatolian Region)

Erzurum, Kars and Ardahan are the inland stations. Continental conditions are dominant in the region and depending upon the continentality degree climatic season durations and vegetation periods in these three stations show great differences in comparison to coastal area.

The inspection of climatic values of **Erzurum** shows that the annual average temperature is 5.4 °C and the temperature in the coldest month of January falls to - 9.6 °C. The average temperature in the hottest month is 19.4 °C. Accordingly the difference between the hottest and coldest months reaches up to 29 °C (Table, 1).

The total annual precipitation is 411 mm in Erzurum with the highest month of May (71 mm). There are 63 days with snow annually and there is snowfall except the period between June and September. But the duration of snow remaining on the ground is very long (112 days) due to the influence of high continentality values (Table, 2).

The inspections of climatic season periods of Erzurum shows that the longest season is winter and the shortest season is autumn. Winter season starts on 21 September and it is influential for a period of eight months continuing until 24 May. Spring season covers the period more than one and a half month between 25 May and 3 July. Summer season starts on 4 July and continues until 22 August. The shortest season is autumn between 23 August and 20 September (Figure, 6).

The vegetation period in Erzurum, where winter is too long, is between 1 May and 16 October. According to this, plants stop growing for nearly half of the year.

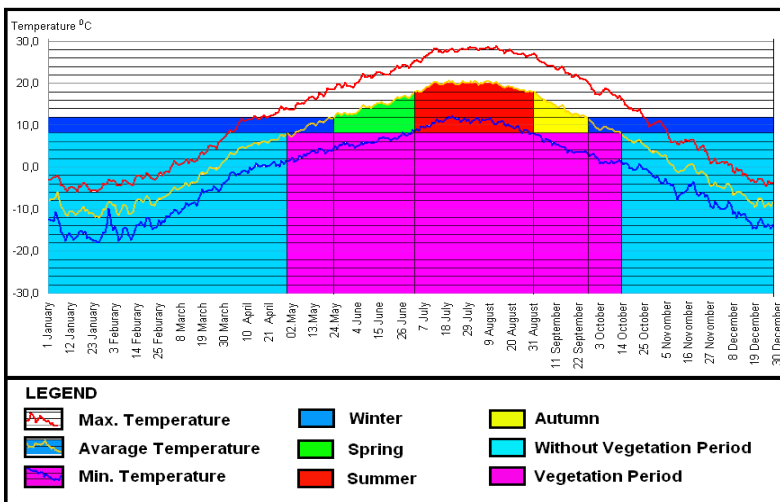


Figure 6. Vegetation and season periods of Erzurum.

Another station situated in inlands is **Kars**. Annual temperature average in Kars is 4.9 °C. While the temperature values in January is -10.2 °C, the temperature in the hottest month of August is 17.8 °C. According to this, as in Erzurum the amplitude value is 29 °C (Table, 1). Annual total precipitation is 483 mm in Kars with the highest amount in May (78 mm) and the lowest amount in January (19 mm). Average number of snowing days is 49 and the duration of snow remaining on the ground is 107.5 days (Table, 2). Continentality effects the duration of snow remaining on the ground. Climatic season durations also show similarities to Erzurum as in the climate values. Winter season starts on 18 September and is influential for a period over eight months continuing until 25 May. Spring season is between 26 May and 11 July, summer season is very brief with 35 days between 12 July and 15 August (Table-3). Autumn season is also too short between 16 August and 17 September (36 days).

Vegetation period in Kars is 4 days shorter than Erzurum because of the increase of continentality effects from west to east. It is between 5 May and 16 October (Figure, 7). Therefore, vegetation period gets shorter with the advance toward east.

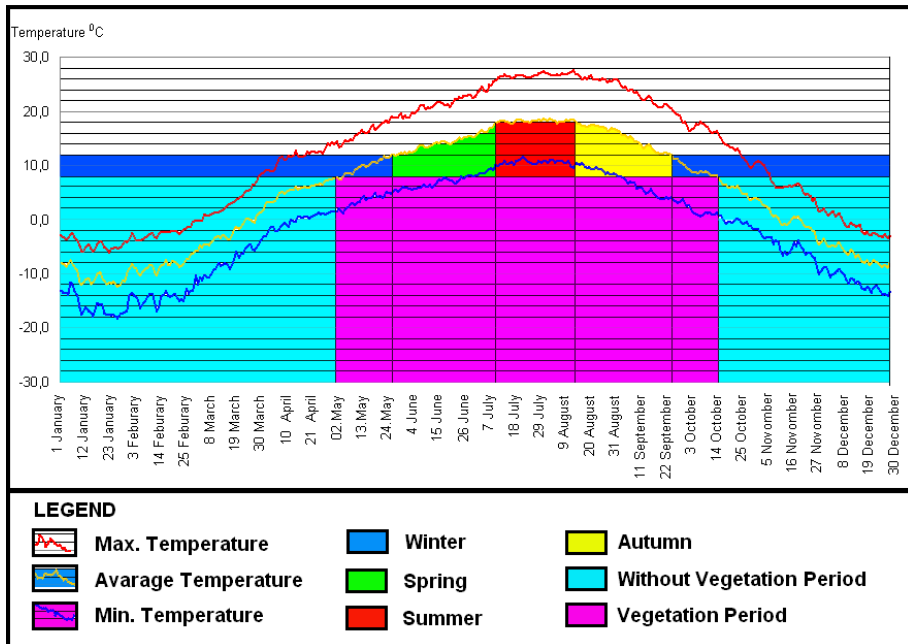


Figure 7. Vegetation and season periods of Kars.

The inspection of climate values in Ardahan which is the last point on the east of the study area show that the annual temperature average falls to 3.7 °C. Average temperature in January is -11.4 °C and in August it is 16.4 °C. Accordingly the amplitude value is 28 °C. Total annual

precipitation value is more than Kars and Erzurum with 547 mm. But, different from these two stations, the highest precipitation month changes to June because of the increase in continentality effects (89.3 mm). The lowest month of precipitation is January (17.4 mm). Average number of snowing days is 44 and the number of snow covered days lasts more than four months and reaches to 127 days (Figure, 2).

The inspection of **climatic season durations** in Ardahan shows very striking results. Winter season, lasting more than eight and a half months, covers the period between 18 September and 5 June (Figure, 3). The most remarkable point for Ardahan is that **there is no summer season in real sense**. Because; long annual daytime temperature values show that the temperature does not reach 18 °C in Ardahan. According to this, **spring and autumn season are combined without entering through summer (Figure, 8)**. Thus, spring is between 6 June and 5 August and autumn is between 6 August and 17 September in Ardahan.

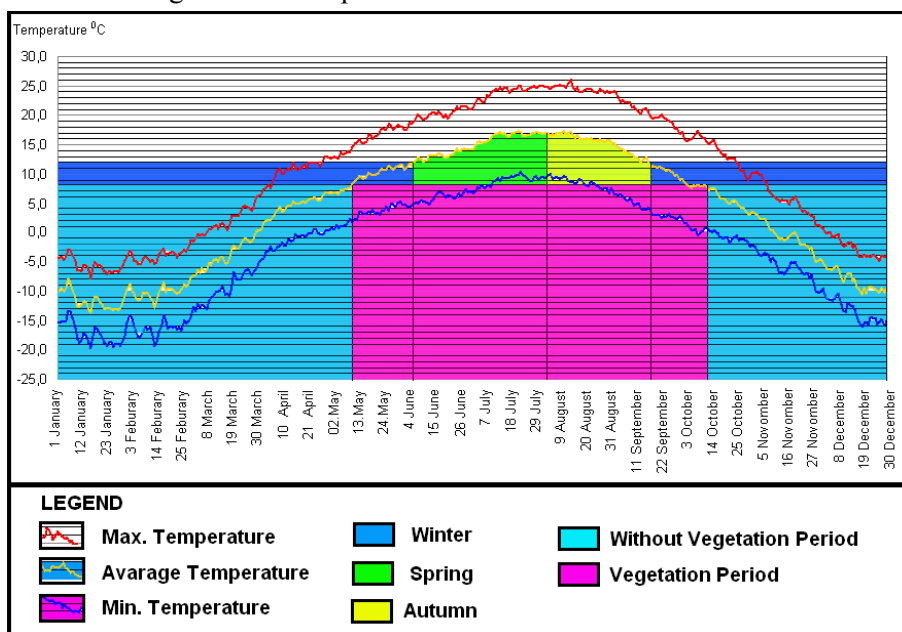


Figure 8. Vegetation and season periods of Ardahan.

3. DISCUSSION AND CONCLUSION

Turkey, as a country of middle latitude, is a peninsula situated between three continents. The reasons for the variety of climates in Turkey include the existence of temperate zone on the north and subtropical zone on the south and the country is surrounded by seas on three sides and interlocked to Asia continent on the east. Also, the mountain ranges split by

depressions on the north and south of the country prevent maritime effects to infiltrate to the midlands and cause climate changes in short ranges.

The study area is situated on the northeast of Turkey between the Black Sea Region where the temperate climate is in effect with precipitation every season and the Eastern Anatolian Region where the continental climate is dominant. For this reason, there is a great difference between the climate values of the stations in the study area and as a result between the starting and finishing dates of climatic season durations and vegetation periods.

The coldest month in the coastal stations of Trabzon and Rize is February due to the maritime effects and the inland stations of Erzurum, Kars and Ardahan have January as the coldest month. While the number of snowing days in the coastal stations is around 10, this number reaches to 1.5 – 2 months in inland stations. The number of snow covered days is 6–10 on the coast and more than 100 days in midland stations and in Erzurum it remains more than three months. Snow does not remain on the ground for a long time due to maritime and melts in a short time on the coast but continentality effects prolong this period in midlands.

Trabzon and Rize, with precipitation all seasons, receive maximum precipitation in November. In Erzurum, maximum precipitation occurs in May due to continentality. In Ardahan, precipitation is delayed to June since the effects of continentality are stronger.

Climatic season periods in the study field do not conform to calendar seasons. The starting and finishing dates of the seasons in Trabzon and Rize show similarities to each other. According to this, winter starts after the ninth of November and lasts nearly for five months (Table, 3). Spring is influential for one and a half month until the end of May. After a short spring, these coastal stations continue with summer season which lasts for nearly four months (until the end of September). Autumn is influential for the remaining one and a half months (nearly forty days).

Table 3. Number of seasons and unvegetative days according to the stations.

Station	RİZE	TRABZON	ARDAHAN	ERZURUM	KARS
<i>Winter</i>	151	147	257	244	240
<i>Spring</i>	46	50	52	39	48
<i>Summer</i>	127	124	0	59	35
<i>Autumn</i>	40	44	53	23	42
<i>Without Vegetation Period</i>	90	75	215	194	194

As the climatic season periods of inland stations show differences from the coast, there is also great difference among themselves which is a striking result of short range climate changes. Winter season is influential in Erzurum and Kars for a long period of nearly eight months. While the spring season in Erzurum is forty days, it is 45 days in Kars. Summer lasts for 48 days in Erzurum but the effects of continentality increase with the move to the eastward and in Kars it is shortened to 35 days (Figure, 4). Autumn does not last for one month in Erzurum (27 days) but it is 31 days in Kars. The most interesting station situated in midlands is **Ardahan**. Winter in Ardahan starts in the middle of September and lasts nearly for nine months until the first week of June. According to the long annual daily average temperature results, spring and summer seasons in this station unite without reaching 18 °C or more. In other words, **it is found out that Ardahan does not experience summer in real sense. The most important reasons for this situation include the location of Ardahan on the northeast of Turkey, on the inner region crossing between Anatolian peninsula and Asia continent and also continental conditions in Turkey increase from west to east. Furthermore, the increase of continentality on the east of Turkey from north to east, contrary to the global trend, causes these results.**

Great differences have been found out in vegetation periods like the season durations. The longest vegetation period is experienced in Trabzon where the maritime effects are the strongest (291 days). Vegetative period plants in Rize is very long (271 days). But it is striking that the growth and development of plants shorten by moving eastward. According to this, vegetation period in Erzurum decreases to 196 days, in Kars to 192 days and in Ardahan to 186 days.

The inspection of statistical significance levels shows that the duration of spring is shortened due to continentality and there is a strong relation between the changes in the durations of seasons and continentality. On the contrary, maritime has a meaningful relation with the prolongation of spring and a strong meaningful relation with the prolongation of vegetation periods.

There are many factors influential in the distinction of climate conditions in Turkey and the changes among regions cause assortments of climate. As a result, climate is influential in marking the physical features such as natural vegetation, structure of the soil, flow regimes and also many human activities notably habitation and economical activities. For this reason, a mosaical structure has developed in Turkey in respect of physical features and human activities.

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