Global Warming and Climate Change: A Practical Study on Bartin, Zonguldak and Düzce

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Abstract

Global warming is regarded as one of the most important problems of our century. In almost all scientific circles and media organizations, there is a common opinion that the world is getting warmer. It is estimated that the world temperature will increase between 1.5 °C and 5.0 °C during the 21st century. In Turkey around 2030, it is reported that the summer and winter temperatures will increase around 2.0 °C-3.0 °C, winter precipitation will increase by up to 10%, summer precipitation will decrease and, the drought in terms of soil moisture will increase. In this study, the minimum, maximum and average temperature values and maximum and total precipitation amounts between 1980-1999 and 2000-2015 for the central meteorological stations of Bartin, Zonguldak and Düzce Provinces in Western Black Sea Region of our country were examined. The results indicate the marked increases in minimum and maximum temperatures monthly basis. At the same time, increasing tendency was determined in the Bartin, Zonguldak and Düzce monthly and annual average temperature data, especially during the summer months. On the other hand, in the period between 1980-1999 and 2000-2015 years monthly and annual, especially during the summer months (June, July and August), average precipitation data showed a tendency to decrease. Turkey is among the riskiest countries from the point of the possibility to experience the potential consequences of global warming. Unless measures are taken against climate change, it will be inevitable that the climate change would degrade the composition and productivity of the natural ecological systems in our country and reduce biological diversity.

Keywords: Global warming, average temperature, precipitation amount, greenhouse gases, Bartin, Düzce, Zonguldak provinces.

Küresel Isınma ve İklim Değişikliği: Bartin, Zonguldak ve Düzce Yöresine Ait Örnek Bir Çalışma

Öz

Küresel ısınma, yüzyılımızın en önemli sorunlarından biri olarak kabul edilmektedir. Hemen hemen tüm bilimsel çevreler ve medya kuruluşlarında, Dünya'nın giderek ısındığı konusunda ortak bir görüş söz konusudur. Dünya sıcaklığının 21. yüzyılda 1.5 °C ile 5.0 °C arasında artacağı tahmin edilmektedir. Türkiye'de ise 2030 yılı dolaylarında yaz ve kış sıcaklıklarının 2.0 °C-3.0 °C civarında, kış yağışlarının ise %10'a kadar artacağı, yazın yağışların azalacağı ve toprak nemi bakımından kuraklığın artacağı bildirilmektedir. Bu çalışmada, ülkemizin Batı Karadeniz Bögesi'nde yer alan Bartin, Zonguldak ve Düzce İllerinin merkez meteoroloji istasyonlarına ait 1980-1999 ve 2000-2015 yılları arasındaki minimum, maksimum ve ortalama sıcaklık değerleri ile maksimum ve toplam yağış miktarları incelenmiştir. Sonuçlar, aylar bazında minimum ve maksimum sıcaklıklarda belirgin artışların olduğunu işaret etmektedir. Bununla birlikte, Bartin, Zonguldak ve Düzce İllerinin aylık ve yıllık ortalama sıcaklık verilerinde, özellikle yaz aylarında artış eğilimi tespit edilmiştir. Diğer taraftan, 1980-1999 ve 2000-2015 yılları arasındaki periyotlarda aylık ve yıllık ortalama yağış verilerinde, özellikle yaz aylarında (Haziran, Temmuz ve Ağustos) azalış eğilimi ortaya çıkmıştır. Türkiye'miz, küresel ısınmanın potansiyel etkilerinin görülme ihtimali açısından, riskli ülkeler arasında yer almaktadır. İklim değişikliklerine karşı gerekli önlemler alınmaz ise, iklim değişikliğinin ülkemizdeki doğal ekolojik sistemlerin bileşimini ve üretkenliğini bozması ve biyolojik çeşitliliği azaltması kaçınılmaz olacaktır.

Anahtar Kelimeler: Küresel ısınma, ortalama sıcaklık, yağış miktarı, sera gazları, Bartin, Düzce, Zonguldak illeri.

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1. Introduction

It has emerged very important issues as a result of extreme exploitation of natural resources by people and thus disrupting the natural balance. The core instances of these problems are starvation, thirst, extinction of living species, destruction of vegetation and soil, global warming and climate change, ozone depletion and perforation, as well as environmental pollution (Hekimoğlu and Altındeğer, 2008). A new problem has been added to the basic ecological problems of organisms, especially human beings along the last 10-15 years. This is called "Global Warming and Global Climate Change". As a result of the increase of some gases, which are occurring as a result of various activities of people and described as greenhouse gases (CO_2, CH_4, H_2O, N_2O, CFC and aerosol), the atmospheric layers near the earth decrease and the anthropogenic increase of the solid earth's temperature are discussed due to global warming. Contrary to the long geological cycles of world climate, influenced by other climate elements (air movements, precipitation, moisture, etc.) at the end of global warming, the global warming that expresses a rapid change in a very short period like the last 15-20 years is a global climate change. In a more narrow sense, this term also implies a dramatic change for the other climate elements mentioned above in all lands and waters, together with the temperature increase (Çepel, 2003; Türkeş, 2010). In almost all scientific environments and media organizations, there is a common view that the world is getting warmer. Therefore, one of the most important problems of the century is global warming. It is accepted that the world temperature has increased by 0.6 ± 0.2 °C in the last century (until the end of 2000). This increase has risen to 0.74 ± 0.18 °C during the past one hundred year period ending in 2005. Hence, it is estimated that this increase will be between 1.5 °C and 5.0 °C in the 21st century (IPCC, 2001, Sağlam et al., 2008; Sarıyıldız et al., 2008). The high rates of variation are due to the generation of different scenarios for future greenhouse gas emissions and the use of different climate sensitivity models (Sağlam et al., 2008). On the other hand, a number of emissions scenarios (IPCC, 2000 and 2007), developed under the IPCC Special Report on Emissions Scenarios (SRES), predict a warming of about 0.2 °C/10 years for the next 20 years. Hereby, the increases in average temperature will lead to both increases in warmer weather conditions and record-level hot air fluctuations, as well as a reduction in the number of frosty days and a less effective and shorter duration of cold air waves. In this sense, it is likely that in the future, it will be warmer days and more intense (larger-area and long-term temperature) hot weather the waves be less cold and less frosty days in almost all land areas (Türkes, 2010). In addition, there will be very different results consequences reaching catastrophic events due to the rising sea level, changes in temperature and precipitation regimes. The overflows, floods, droughts and ultimately desertification, storms and epidemics of biologically based origin disasters are some of these catastrophis events. These disasters will spread to wider areas and will be experienced more frequent (Öztürk, 2002).

The increasing tendency observed in the average global temperature does not exhibit equally geographical distribution throughout the world. Longer warming tendencies are more frequent between 40º and 70º northern latitudes. In other words, the greatest impacts of climate change will emerge in the middle and high latitude countries (Karabulut and Cosun, 2009, Kızılelma et al., 2015). Turkey, itself possessing the complex structure of the climate, is one of those countries that will be greatly be affected by climate change, especially due to global warming. Due to the fact that Turkey is naturally surrounded by the sea on three sides, and has a fragmented topography and orographic characteristics, it is expressed that the different regions of Turkey will be affected in different ways by climate change (Türkeş, 2000). In Turkey around 2030, dependent upon the global warming and, accordingly upon the predictions on how global climate change might affect Turkey's climate, it is emphasized that the summer and winter temperatures will increase around 2.0 °C-3.0 °C, the winter precipitations will increase up to 10%, precipitation will decrease in summer and so drought in terms of soil moisture will increase (Çepel, 2003). Thus, as the consequences of climate change grow, the severity of the negative effects will also increase. Socio-economic sectors (eg., agriculture, forestry, fisheries, water resources and human settlements), land and water ecosystems will also become very sensitive to the size and speed of climate change (Türkeş, 2012). Furthermore, it is stated that temperatures that are too low below normal or too high above normal, will lead to various harmful effects on living things, especially on plants (Çepel, 1995). In this study, in order to determine whether there are any changes in the minimum, maximum and average temperature values and maximum and total precipitation amounts between 1980-1999 and 2000-2015 for central meteorological stations of Bartin, Zonguldak and Düzce Provinces in Western Black Sea Region of our country were queried.

2. Material and Method

2. 1. Locations and Boundaries of Research Areas

Bartin lies between 41° 53' northern latitude and 32° 45' eastern longitude of the Western Black Sea Region. The north of Bartin is surrounded by the Black Sea along a 59 km coastline. Bartin is neighbor to Kastamonu province in

the east, the Karabük province in the east and south, and also a Zonguldak province in the west. The city center is at 25 m altitude (URL-1, 2017). Zonguldak province, which is located in the Western Black Sea Region of our country is surrounded by the Bartin province in the east, the Karabük province in the south, the Bolu province in the south, the Düzce province in the west and the Black Sea in the north. The Zonguldak province is located between 41° - 41° 48' northern latitude and 31° 10' - 32° 50' eastern longitude (Deniz, 2014).
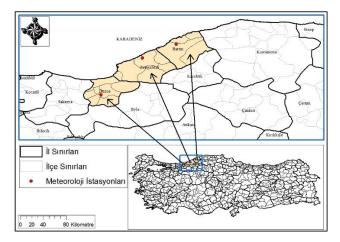

Figure 1. The location of the research areas in our country.

The Düzce provincial center is located at 39°-51' northern latitude 31°-08' eastern longitude. Düzce is located at the north of the Black Sea. The Black Sea lies to the north of Düzce. The Düzce Province is taking place in the west and north of Bolu Province lands, east of Sakarya Province and southwest of Zonguldak Province. The altitude of Düzce is 160 m above the sea level (URL-2, 2017) (Figure 1).

2. 2. Meteorological Data

In this study, data from 1980-1999 and 2000-2015 years (periods) belonging to Bartin, Zonguldak and Düzce Meteorology Station Directorate of General Directorate of Meteorology were used. Monthly average minimum, monthly average maximum, minimum temperature, maximum temperature, monthly average temperature and annual average temperature, monthly average maximum precipitation, monthly average total precipitation and total annual rainfall values were calculated from the data of three central stations that were observed synoptically or automatically between 1980-1999 and 2000-2015. The period average is calculated as the arithmetic average of the corresponding periods and also the annual average is calculated as the arithmetic average of the twelve months in the calendar year. Some information about the stations is given in Table 1. Also; Their location, in Turkey is given in Figure 1.

Table 1. Information on the stations used in the study (URL-3, 2017).

Sequence Number	Station Name	Station Number	Altitude (m)	Latitude (North)	Longitude (East)
1	Bartin	17020	33	41.6248	32.3569
2	Zonguldak	17022	135	41.4497	31.7779
3	Düzce	17072	146	40.8437	31.1488

3. Results and Discussion

3. 1. Minimum, Maximum, Monthly Average and Yearly Average Temperature

The average minimum temperature in the Bartin province between 1980-1999 was measured at -0.2 °C in February. Also, the minimum temperature was measured as -18.8 °C on 23 February 1985. The average minimum temperature measured between 2000 and 2015 was obtained in January at 0.6 °C. On the other hand, the minimum temperature observed in the period concerned is -15.6 °C on 2 February 2012. The average minimum temperature, the minimum temperature and the information about the measured minimum temperature of the day and year for the other months is given in Table 2. As can be seen in the Table 2, it will be understood that both the average minimum temperature and the minimum temperature values measured between 2000 and 2015 are relatively higher than both the average

minimum temperature and the minimum temperature values measured between 1980 and 1999 years. For example, the average minimum temperature difference between the two periods in March is 0.8 °C. Based on this information, it can be said that there is an increasing tendency for both the average minimum temperatures and for the minimum temperatures. The minimum temperature is called the minimum value of the temperature detected during the observation period. In other words, the minimum temperature is called as its lowest value within from one day before the 21:00 start time of observation to the minimum temperature to be taken during the period up to the day of the observation time of 21:00. Çepel (1995) expresses to the lowest temperature that a living thing can live actively as "the lowest effective temperature". Temperatures that are too low below normal give rise to various harmful effects on the organism, especially in plants. If the temperature falls slightly below the minimum effective temperature limit, the living beings can enter the freezing coma. However, suffering of plants the from the low temperatures, depend on the plant species, the lowest temperature, the physiological conditions at which the low temperature occurs (the water content of the tissues, the day length etc.).

Table 2. Information about average minimum temperature, minimum temperature degree, day and year belonging to the province of Bartin between 1980-1999 and 2000-2015.

Months	Between 1980 and 1999 years			Between 2000 and 2015 years		
	Average minimum temperature (°C)	Minimum temperature (°C)	Minimum temperature the day and year	Average minimum temperature (°C)	Minimum temperature (°C)	Minimum temperature the day and year
January	0.3	-12.5	26.01.1987	**0.6**	-12.7	27.01.2010
February	**-0.2**	**-18.8**	**23.02.1985**	0.9	**-15.6**	**02.02.2012**
March	1.9	-13.1	02.03.1985	2.7	-6.8	08.03.2004
April	5.8	-4.5	01.04.1981	6.0	-4.4	05.04.2004
May	9.7	-1.3	02.051985	10.1	0.9	09.05.2000
June	13.2	5.6	03.06.1997	13.9	5.3	11.06.2004
July	15.4	8.0	02.07.1985	16.5	9.0	02.07.2004
August	15.1	6.7	30.08.1984	16.6	9.5	30.08.2012
September	11.5	1.5	30.09.1986	13.3	5.0	12.09.2004
October	8.7	-1.0	31.10.1985	9.4	-0.9	28.10.2011
November	4.1	-5.0	12.11.1995	4.8	-5.5	26.11.2011
December	2.2	-8.6	24.12.1992	1.6	-9.3	27.12.2002

The average maximum temperature between 1980-1999 years was 27.8 °C in August for Bartin province. The maximum temperature during this period was measured as 40.1° C on August 12, 1994. The average maximum temperature observed between 2000 and 2015 years was again measured in August as 29.5 °C. The maximum temperature between this period was 42.8 °C on July 13, 2000. The average maximum temperature, maximum temperature, and the information on the day and the year when the maximum temperature was measured in the other months are presented in Table 3. As can be seen from Table 3, the average maximum temperature values and the maximum temperature values measured between 2000 and 2015 years are relatively higher than the average maximum temperature values and the maximum temperature values measured between 1980 and 1999 years. For instance, the average maximum temperature difference between these two periods during February was about 1.5 °C. On account of this, it can be said that there is an increasing tendency in average maximum temperatures and maximum temperatures. The maximum temperature is called the maximum value of the temperature picked out during the observation period. In other words, the maximum temperature is called as its highest value within the duration along one day before the 21:00 start time of observation to the maximum temperature to be taken during the period up to the day of the observation time of 21:00.

Çepel (1995) describes the highest temperature as a living creature can normally sustain its the life under "the highest effective temperature". Temperatures that are too high above normal cause a variety of harmful effects on living things, particularly in plants. Physiological explanations of the damages that the extreme temperatures can cause the plants suffer are as follows: As temperature increases, respiration and transpiration increase. The increase in respiration increases the metabolic activity of plants leading to the consumption of energy for respiration, and therefore leading to the consumption of more water and organic matter. The water required for transpiration rising with increasing temperature can not be supplied. Nomitalely, the water consumed by transpiration exceeds the water that can be taken from the roots. As a result, the death of the plant occurs following the water shortage and the limited nutrient uptake.

Table 3. Information about average maximum temperature, maximum temperature degree, day and year belonging to the province of Bartin between 1980-1999 and 2000-2015.

Months	Between 1980 and 1999 years			Between 2000 and 2015 years		
	Average maximum temperature (°C)	Maximum temperature (°C)	Maximum temperature the day and year	Average maximum temperature (°C)	Maximum temperature (°C)	Maximum temperature the day and year
January	8.8	22.4	02.01.1995	9.8	22.2	21.012013
February	9.4	23.6	23.02.1996	10.9	25.8	20.02.2010
March	12.3	31.2	19.03.1981	13.9	31.6	31.032013
April	17.5	34.1	09.04.1998	18.1	33.7	11.04.2004
May	21.8	36.7	27.05.1990	22.7	34.9	31.05.2013
June	25.5	36.1	27.06.1996	26.5	38.0	24.06.2009
July	27.4	39.8	27.07.1987	29.3	**42.8**	**13.07.2000**
August	**27.8**	**40.1**	**12.08.1994**	**29.5**	37.6	14.08.2005
September	24.4	36.0	13.09.1998	25.8	37.8	06.09.2015
October	20.2	33.8	04.10.1994	21.0	37.1	06.10.2003
November	14.5	29.0	07.11.1993	16.7	28.6	10.11.2010
December	10.8	22.7	01.12.1980	11.6	27.7	02.12.2010

The average minimum temperature in the Zonguldak province was measured as 2.6 °C in February between 1980-1999 years. The minimum temperature was also measured as -7.0 °C on 23 February 1985. The average minimum temperature detected between 2000 and 2015 years was again measured in February at 3.7° C. On the other hand, the minimum temperature observed within that period was -6.7 °C on 15 February 2004.

Table 4. Information about average minimum temperature, minimum temperature degree, day and year belonging to the province of Zonguldak between 1980-1999 and 2000-2015.

Months	Between 1980 and 1999 years			Between 2000 and 2015 years		
	Average maximum temperature (°C)	Maximum temperature (°C)	Maximum temperature the day and year	Average maximum temperature (°C)	Maximum temperature (°C)	Maximum temperature the day and year
January	3.5	-5.4	09.01.1982	4.0	-4.9	24.01.2004
February	**2.6**	**-7.0**	**23.02.1985**	**3.7**	**-6.7**	**15.02.2004**
March	4.2	-6.4	07.03.1987	5.3	-3.4	24.03.2003
April	8.1	-0.6	10.04.1997	8.4	-2.1	05.04.2004
May	12.0	3.2	05.05.1995	12.6	5.0	09.05.2008
June	15.9	8.8	03.06.1994	16.4	10.0	20.06.2000
July	17.8	11.2	15.06.1993	19.2	13.6	05.07.2006
August	17.9	11.1	30.07.1984	19.4	13.4	27.08.2000
September	15.1	6.6	30.08.1986	16.3	10.1	12.09.2004
October	12.2	2.8	26.09.1991	12.7	1.8	29.10.2003
November	8.0	-0.8	12.10.1993	9.3	-0.2	22.11.2005
December	5.6	-3.2	12.12.1989	5.7	-3.7	31.12.2015

The average minimum temperature, minimum temperature and the day and the year when the minimum temperature is detected for the other month are shown in Table 4. As can be seen from Table 4, it will be realized that both the average minimum temperature values and the minimum temperature values observed between 2000 and 2015 years were relatively higher than both the average minimum temperature values and the minimum temperature values observed between 1980-1999 years. As an example, the average minimum temperature difference between the two periods during March was 1.1 °C. Depending on this information, it can be said that Zonguldak province has an increasing tendency both for the average minimum temperatures and for the minimum temperatures.

The average maximum temperature in the Zonguldak province between 1980 and 1999 years was 24.8 °C for August. The maximum temperature during this period was measured as 35.6 °C on May 31, 1980. The average maximum temperature observed between 2000 and 2015 years was 26.5 °C, again measured for August. The maximum temperature between this period was 39.5 °C on July 13, 2000. The measured average maximum temperature, maximum temperature, data about the day and the year when the maximum temperature is observed in the other months are presented in Table 5. As can be seen in Table 5 for some months, it is understood that both the average maximum temperature values and the maximum temperature values detected between 2000 and 2015 years are relatively higher than both the average maximum temperature values and the maximum temperature values detected between 1980-1999 years. For example, the average maximum temperature difference between the two

periods in July is about 1.6 °C. Depending on all these, it can be said that there is an increasing tendency in average temperatures and maximum temperatures in Zonguldak province.

Table 5. Information about average maximum temperature, maximum temperature degree, day and year belonging to the province of Zonguldak between 1980-1999 and 2000-2015.

Months	Between 1980 and 1999 years			Between 2000 and 2015 years		
	Average maximum temperature (°C)	Maximum temperature (°C)	Maximum temperature the day and year	Average maximum temperature (°C)	Maximum temperature (°C)	Maximum temperature the day and year
January	9.2	23.0	02.01.1982	9.4	24.1	01.012010
February	8.5	24.3	11.02.1983	9.6	26.7	20.02.2010
March	10.2	29.9	19.03.1981	12.0	29.8	26.03.2001
April	14.9	32.4	09.04.1998	15.3	33.6	22.04.2008
May	18.7	**35.6**	**31.05.1980**	19.2	33.2	23.05.2013
June	22.9	34.4	28.06.1980	23.4	36.2	28.06.2007
July	24.6	34.6	07.07.1997	26.2	**39.5**	**13.07.2000**
August	**24.8**	34.8	12.08.1994	**26.5**	35.2	12.08.2002
September	22.0	33.8	12.09.1993	23.3	34.0	01.09.2003
October	18.5	34.7	07.10.1992	19.0	35.9	06.10.2003
November	14.2	26.6	07.11.1993	15.6	29.9	14.11.2004
December	11.3	24.2	27.12.1995	11.6	28.1	02.12.2010

The average minimum temperature between 1980-1999 years in Düzce province was measured as 0.4 °C for January and February. The minimum temperature was also measured as -17.3 °C on 23 February 1985. The average minimum temperature observed between 2000 and 2015 years was measured in January at 0.9 °C. The minimum temperature observed within the same period in Düzce was -13.9 °C on 27 January 2010. The average minimum temperature, the minimum temperature and the information about the measured minimum temperature of the day and year for the other months is displayed in Table 6. As can be seen in the Table 6, according to the months, it is understood that both the average minimum temperature and the minimum temperature values detected between 2000 and 2015 years are relatively higher than both the average minimum temperature and the minimum temperature values detected between 1980 and 1999 years. As an example, the average minimum temperature difference in May between the two periods is 0.5 °C. Depending on this knowledge, it can be understood that there is an increasing tendency in Düzce province both at average minimum temperatures and at minimum temperatures. The average maximum temperature in the Düzce province between 1980-1999 years were measured as 28.2 °C for August. The maximum temperature during this period was detected as 40.0 °C on August 12, 1994. The average maximum temperature measured between 2000 and 2015 years was again detected for August at 30.5 ° C. The maximum temperature during this period was 42.2 °C on July 13, 2000. The average maximum temperature, maximum temperature, and the knowledge about the day and the year when the maximum temperature is measured in the other months are given in Table 7.

Table 6. Information about average minimum temperature, minimum temperature degree, day and year belonging to the province of Düzce between 1980-1999 and 2000-2015.

Months	Between 1980 and 1999 years			Between 2000 and 2015 years		
	Average minimum temperature (°C)	Minimum temperature (°C)	Minimum temperature the day and year	Average minimum temperature (°C)	Minimum temperature (°C)	Minimum temperature the day and year
January	**0.4**	-15.0	01.01.1993	**0.9**	**-13.9**	**27.01.2010**
February	**0.4**	**-17.3**	**23.02.1985**	1.7	-12.0	02.02.2012
March	2.8	-13.6	02.03.1985	3.8	-6.7	23.03.2003
April	7.0	-3.0	11.04.1997	7.3	-2.5	05.04.2004
May	10.9	0.4	01.05.1985	11.4	2.8	04.05.2005
June	14.3	6.6	02.06.1994	15.1	6.7	21.06.2000
July	16.6	8.8	03.07.1982	17.6	11.4	02.07.2000
August	16.5	7.6	31.08.1981	17.9	10.4	30.08.2012
September	12.8	4.5	29.09.1992	14.2	6.8	13.09.2004
October	9.5	-0.2	30.10.1996	10.2	-0.2	30.10.2003
November	4.6	-6.8	14.11.1988	5.5	-4.3	15.11.2011
December	2.5	-16.5	31.12.1992	2.0	-12.4	27.12.2002

As can be seen for Table 7, it can be seen that both the average maximum temperature values and the maximum temperature values measured between 2000 and 2015 years are relatively higher than both the average maximum temperature values and the maximum temperature values measured between 1980 and 1999 years. For instance, the average maximum temperature difference between the two periods during October was approximately 1.1 °C. According to these results, it can be said that there is an increasing tendency in average maximum temperature and maximum temperature in Düzce province.

Table 7. Information about average maximum temperature, maximum temperature degree, day and year belonging to the province of Düzce between 1980-1999 and 2000-2015.

Months	Between 1980 and 1999 years			Between 2000 and 2015 years		
	Average maximum temperature (°C)	Maximum temperature (°C)	Maximum temperature the day and year	Average maximum temperature (°C)	Maximum temperature (°C)	Maximum temperature the day and year
January	7.7	23.4	02.01.1995	9.0	24.5	01.01.2010
February	9.1	23.6	23.02.1996	11.2	25.6	20.02.2010
March	12.5	30.2	31.03.1983	14.6	32.2	26.03.2001
April	18.4	34.2	12.04.1998	19.2	34.4	05.04.2000
May	22.6	37.5	31.05.1980	24.2	35.8	31.05.2013
June	26.4	38.0	05.06.1994	27.7	38.9	28.06.2007
July	28.0	38.2	09.07.1996	30.3	**42.2**	**13.07.2000**
August	**28.2**	**40.0**	**12.08.1994**	**30.5**	39.9	05.08.2006
September	25.3	37.8	14.09.1998	26.7	38.3	01.09.2003
October	20.2	35.5	07.10.1992	21.3	38.2	06.10.2003
November	14.2	28.8	07.11.1993	16.4	28.7	10.11.2010
December	10.0	23.1	27.12.1995	10.3	29.2	02.12.2010

As tried to be expressed above, both the average minimum and average maximum temperatures as well as minimum and maximum temperatures vary between 1980-1999 and 2000-2015 years on a monthly basis in Bartin, Zonguldak and Düzce provinces. Both the average minimum temperatures and the average maximum temperatures have increased relatively between 1980-1999 and 2000-2015 years. In addition, monthly extreme air temperatures (the lowest and highest temperatures) tend to increase in related periods. In this study, similar results were obtained with previous studies. For example, in a study conducted byTürkeş (2012), it is emphasized that in Turkey the lowest air temperature at night and the highest air temperature at daytime are increasing, especially with 1990's. In a study conducted by Demir et al. (2008), it has been determined that the minimum temperatures in Turkey generally tend to increase, which is significant in 27 stations. In addition, it has been determined in the study that the annual maximum temperature sequences are generally increasing in the Mediterranean, Southeast Anatolia and southern parts of Eastern Anatolia. A study of the long-term trends of maximum temperatures by Cosun and Karabulut (2009) found significant increases in maximum temperatures at 95% confidence in Kahramanmaraş and 90% confidence in Afşin. It is also expressed in the study that increases in minimum temperatures are more pronounced than increases in maximum temperatures.

The annual average temperature of the Bartin province between 1980-1999 years was 12.4 °C, while the average temperature between 2000-2015 years was 13.2 °C. According to the previous 20-year period (between 1980-1999), the average annual temperature has increased by 0.8 °C over the last 15 years (Figure 2A). The average temperature in the Bartin province between 1980 and 2015 years was 12.8 °C. The annual average temperature of the Zonguldak province between 1980-1999 years were found to be 13.4 °C, while the average temperature between 2000 and 2015 years was determined to be 14.1 °C. The average annual temperature in the last 15 years has increased by 0.7 °C compared to the previous 20 year period (Figure 2B). In the Zonguldak province the average temperature between 1980 and 2015 was 13.7 °C. The average annual temperature of the Düzce province between 1980-2000 years were determined as 12.9 °C, and the average temperature between 2000-2015 years were determined as 13.9 °C. The annual average temperature has risen by 1.0 °C over the past 15 years, compared with the average annual temperature over the previous 20 year (Figure 2C). The average temperature between 1980 and 2015 years was determined as 13.4 °C in Düzce province. As will be apparent from the description made so far, there was an upward trend in monthly and annual average temperature values of Bartin, Zonguldak and Düzce province during the periods between the years 1980-1999 and 2000-2015, especially during the summer months.
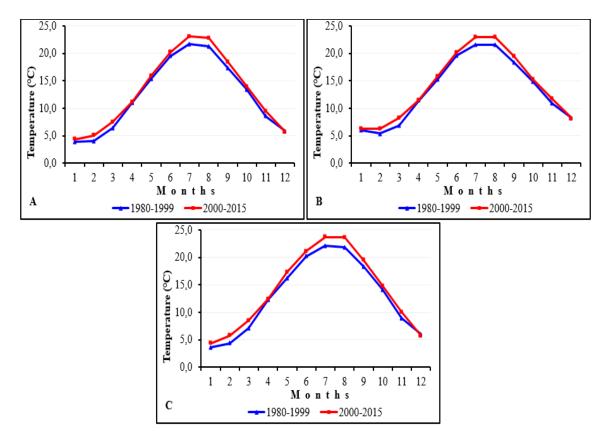
Figure 2. Monthly average temperature values of Bartin (A), Zonguldak (B) and Düzce (C) between 1980-1999 and 2000-2015.

Taking into account three different provinces, the annual average temperature has increased by 0.7 to 1.0 °C from 1980 to 2015 years. This result supports the prediction which is expressed in a previous study. Thus, it is stated in a study (Türkeş, 2001a) that there may be an increase of about 1 °C to 4 °C in average annual temperatures over Turkey (compared to normal 1961-1990) until 2080. In addition, as can be seen when Figures 2A, B and C are examined, monthly average temperature values between 2000 and 2015years are always higher than average monthly temperature values between 1980 and 1999 years. In Turkey, the coldest (average temperature is 11.4 °C) year and the hottest (average temperature is 15.1 °C) year between 1979 and 2015 are 1992 and 2010 years, respectively. The average temperature in Turkey between 1979 and 2015 is 13.2 ° C (URL-4, 2017). If the average temperatures of Bartin, Zonguldak and Düzce compare to the average temperature of Turkey (13,2 ° C) between 1979 and 2015 (12.8 °C, 13.7 °C and 134 °C, respectively), Zonguldak and Düzce provinces are a temperature above the average of Turkey, whereas the Bartin province has a temperature below the average of Turkey. It is stated that there is an increasing tendency in the annual average temperature analyzes in the study called "Trend Analysis of Rainfall and Temperature Parameters in Aegean Region " carried out by Tanrıkulu (2016). In another similar study, it is emphasized that there has been a significant increase tendency at the average temperature of Turkey in the southern and southern west regions (Demir et al., 2008). By the way, Türkeş (2001b) expresses that some factors such as fossil fuel burning, deforestation, land use changes, cement production and industrial processes, the atmospheric accumulation of atmospheric greenhouse gases and the contribution of urbanization are considered to increase the surface temperature of the earth by strengthening the natural greenhouse effect.

3. 2. Monthly Maximum Precipitation, Average Total Precipitation and Annual Total Precipitation

The maximum precipitation in the Bartin province between 1980-1999 was measured as 107.2 mm on 4 June 1984. Yet, the maximum precipitation measured between 2000 and 2015 was recorded as 108.6 mm on 15 July 2009. Knowledge about the maximum precipitation, the day and the year when the maximum precipitation is measured in the other months are presented in Table 8. As can be seen for Table 8, it can be seen that the maximum precipitation values detected between 2000 and 2015 years are relatively lower than the maximum precipitation values detected between 1980 and 1999 years. According to these results, it can be expressed that there is a tendency to decrease in maximum precipitation on a monthly basis in Bartin province.

Table 8. Information about maximum precipitation, day and year belonging to the province of Bartin between 1980-1999 and 2000-2015.

Months	Between 1980 and 1999 years			Between 2000 and 2015 years		
	Maximum precipitation (mm)	Maximum precipitation day	Maximum precipitation year	Maximum precipitation (mm)	Maximum precipitation day	Maximum precipitation year
January	39.9	3	1983	54.0	10	2013
February	34.7	2	1991	34.1	18	2012
March	48.3	18	1982	46.3	15	2008
April	30.2	1	1982	20.4	9	2011
May	93.2	21	1998	46.1	28	2015
June	**107.2**	**4**	**1984**	84.9	4	2000
July	74.8	7	1991	**108.6**	**15**	**2009**
August	93.8	28	1982	75.8	12	2004
September	91.8	24	1998	69.4	15	2002
October	77.6	10	1988	109.9	1	2015
November	63.6	13	1984	96.7	5	2006
December	50.9	10	1980	55.1	11	2010

The maximum precipitation in the Zonguldak province between 1980-1999 years was measured as 147.9 mm on 31 October 1981. However, the maximum precipitation measured between 2000 and 2015 was recorded as 114.4 mm on 2 August 2007. The maximum precipitation, the day and the year when the maximum precipitation is measured in the other months are offered in Table 9. When Table 9 is analyzed on a monthly basis, it has been found that the maximum precipitation values observed between 2000 and 2015 years are relatively lower than the maximum precipitation values observed between 1980 and 1999 years. Therefore, it is understood that there is a tendency to decrease in maximum precipitation in the Zonguldak province on a monthly basis.

Table 9. Information about maximum precipitation, day and year belonging to the province of Zonguldak between 1980-1999 and 2000-2015.

Months	Between 1980 and 1999 years			Between 2000 and 2015 years		
	Maximum precipitation (mm)	Maximum precipitation day	Maximum precipitation year	Maximum precipitation (mm)	Maximum precipitation day	Maximum precipitation year
January	43.7	3	1983	55.4	17	2012
February	42.9	22	1988	42.8	11	2015
March	40.0	2	1980	46.9	5	2004
April	36.4	11	1995	30.9	10	2015
May	91.8	21	1998	41.9	28	2015
June	90.5	27	1992	100.4	4	2000
July	113.4	22	1983	56.7	14	2009
August	103.4	28	1982	**114.4**	**2**	**2007**
September	144.2	8	1989	89.6	22	2009
October	**147.9**	**31**	**1981**	81.6	4	2013
November	71.6	21	1994	78.6	25	2004
December	58.2	28	1982	66.4	11	2010

Table 10. Information about maximum precipitation, day and year belonging to the province of Düzce between 1980-1999 and 2000-2015.

Months	Between 1980 and 1999 years			Between 2000 and 2015 years		
	Maximum precipitation (mm)	Maximum precipitation day	Maximum precipitation year	Maximum precipitation (mm)	Maximum precipitation day	Maximum precipitation year
January	55.8	1	1983	60.0	6	2002
February	34.4	20	1999	39.2	14	2004
March	29.1	18	1996	39.0	5	2004
April	29.0	16	1984	30.4	17	2002
May	48.4	21	1998	28.8	1	2014
June	55.3	15	1992	44.5	7	2014
July	53.0	22	1983	51.4	6	2005
August	**100.1**	**13**	**1993**	47.8	29	2012
September	49.7	14	1990	66.9	10	2009
October	55.5	11	1990	**81.0**	**1**	**2015**
November	56.1	9	1986	39.3	21	2001
December	58.9	31	1983	47.0	18	2003

In the Düzce province, the maximum precipitation between 1980-1999 years was measured as 100.1 mm on 13 August 1983. But, the maximum precipitation measured between 2000 and 2015 years was recorded as 81.0 mm on October 1, 2015. Information about the maximum precipitation, the day and the year when the maximum precipitation is measured in the other months are given in Table 10. As can be seen when the table 10 examined by months, It has been found that the maximum precipitation values detected between 2000 and 2015 years were relatively lower than the maximum precipitation values detected between 1980 and 1999 years. In other words, it can be said that there is a tendency to decrease in maximum precipitation on a monthly basis in the Düzce province.

In the Bartin province, the annual average total precipitation between 1980-1999 years was 1043.7 mm, while the average annual precipitation between 2000 and 2015 years was determined as 1068.1 mm. Annual average total rainfall has increased by approximately 24.0 mm over the past 15 years compared to the previous 20-year period (Figure 3A). The average annual total precipitation between 1980 and 1999 in the Zonguldak province was measured as 1265.5 mm, whereas the average annual precipitation between 2000 and 2015 was measured as 1205.8 mm. Annual average total precipitation decreased by 60.0 mm in the last 15 years when compared to the previous 20 years (Figure 3B). The average annual precipitation between 1980-1999 years in the Düzce province was measured as 847.0 mm, while the average annual precipitation between 2000 and 2015 was determined as 775.4 mm. Looking at these results, annual average total precipitation over the last 15 years was 48.0 mm less than in the previous 20 year period (Figure 3C).
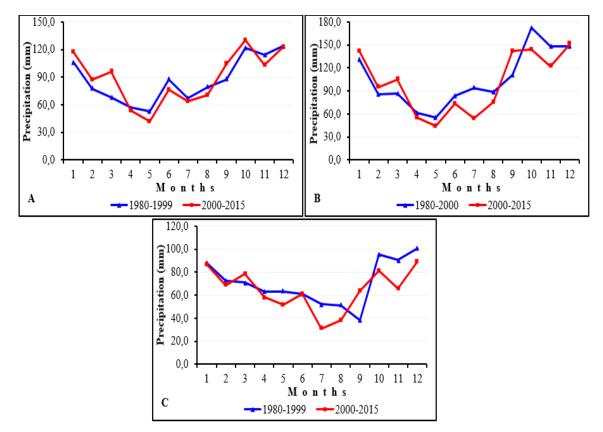

Figure 3. Monthly average total precipitation values of Bartin (A), Zonguldak (B) and Düzce (C) between 1980-1999 and 2000-2015.

Considering three different provinces, annual average total precipitation showed a 24.0 mm increase in the Bartin province from 1980 to 2015 and a decrease of 48.0 to 60.0 mm in the Zonguldak and Düzce provinces. Cosun and Khan (2009) have reported that there is a declining trend in precipitation last 30 years in Turkey. It is reported a study conducted by Türkeş (2001b), there may be approximately a decrease of 0-1 mm/day in the average annual precipitation in Turkey until the year 2080. On the other hand, figure 3A, B and C as it can be seen by examining, the provinces of Bartin, Zonguldak and Duzce were found to have received less precipitation during the 5 month period between the years 2000-2015 until the middle of the 4th month (April) and the 8th month (August) compared to the same time period between 1980-1999. Furthermore, during the period between 1980-1999 and 2000-2015 monthly and annual average precipitation values in Bartin, Zonguldak and Düzce provinces decreased, especially in summer (June, July and August) (Figure 3A, B and C). Turkey has a non-uniform structure in terms of precipitation climatology. Turkey has an average annual rainfall of 654 mm, the annual average precipitation in West Black Sea

Region is 1400 mm. As a result, the precipitation regime in our country is not homogeneous (Kayhan, 2007). Average annual precipitation values of the provinces subject to the study are higher about 60% in Bartin, 90% in Zonguldak and 25% Düzce than that of the average of Turkey. On the other hand, the average annual precipitation per year is lower than the average of the Western Black Sea Region. These results have shown that even the neighboring provinces do not receive equal amounts and proportions of precipitation and there can be differences between them in terms of precipitation.

4. Conclusions

The aim of this study is to determine whether there are any changes in precipitation and temperature, which are the most important indicators of climate change in Bartin, Zonguldak and Düzce provinces, which are adjacent to each other in the Western Black Sea Region. The temporal trends of the temperature and precipitation values of the central stations are examined and the results achieved are summarized as follows:

The minimum temperature values observed between 2000 and 2015 years are relatively higher than the minimum temperature values observed between 1980 and 1999 years. Similarly, it has been found that the maximum temperature values observed between 2000 and 2015 years are relatively higher than the maximum temperature values observed between 1980 and 1999 years. In Bartin, Zonguldak and Düzce provinces, the average annual temperature has increased from 0.7 °C to 1.0 °C over the last 15 years, according to the previous 20-year period. If an assessment is made in general, it is understood that the temperature increases experienced within all over the world are also realized clearly in the study areas. In other words, the temperature increase is compatible with the observed trends in average and extreme temperatures on a global scale. In the above-mentioned province, the maximum amount of precipitation measured between 2000 and 2015 years on a monthly basis was found to be relatively low compared to the maximum amount of rainfall measured between 1980-1999 years. However, annual average total precipitation increased by 24.0 mm in the Bartin province from 1980 to 2015, it showed a decrease of between 48.0 and 60.0 mm in the Zonguldak and Düzce provinces in the same period. Therefore, it can be said that there is a tendency to decrease both the maximum amount of precipitation on a monthly basis and the annual average total amount of precipitation. In fact, in order to bring out the possible changes that climate change will cause on our country climate over many years, the number of studies that are investigating climate change should be increased both in the study area and in our country. In addition, model-based researches in the long-term for this purpose should be performed. Moreover, Turkey is among the riskiest countries in terms of the potential impact of global warming. Unless measures are taken against climate change, it will be inevitable that climate change will degrade the composition and productivity of natural ecological systems and reduce biological diversity in our country.

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