DOI:10.5152/forestist.2023.23005
Forestist 2023

ISTANBUL UNIVERSITY
CERRAHPAŞA

Original Article

Analysis of Some Meteorological Data and Their Variation Trends in Three Provinces of the Western Black Sea Region Between 2012 and 2021

İlyas Bolat[1], Hüseyin Şensoy[2]

[1]Division of Soil Science and Ecology, Department of Forest Engineering, Bartın University Faculty of Forestry, Bartın, Türkiye
[2]Division of Watershed Management, Department of Forest Engineering, Bartın University Faculty of Forestry, Bartın, Türkiye

ABSTRACT

Many recent studies report that the world has been warming on a local, regional, continental, and global scale with an increase in extreme precipitation and temperatures, posing serious risks. This study was carried out in three provinces located in the Western Black Sea region for the purpose of identifying regional changes in some climatic parameters including monthly minimum, average and maximum temperatures, and monthly average minimum, maximum, and total annual precipitation in the last decade (2012–2021). The provinces in the study include Bartın, Zonguldak, and Düzce. The year with the highest average temperature was 2018 in Bartın (14.39°C), 2019 in Zonguldak (15.47°C), and 2018 in Düzce (15.35°C). The results of the simple linear regression model indicated an increasing trend in the average minimum and maximum temperature and the annual average temperature in all three provinces (Bartın; $r = .568$, Zonguldak; $r = .653$, Düzce; $r = .584$). The regression analysis performed to identify the variation in the average total precipitation over the years revealed that the average total precipitation had a decreasing trend in Bartın ($r = -.081$) yet an increasing trend in Zonguldak ($r = .423$) and Düzce ($r = .306$). The study results suggest that, on a regional scale, the temperatures tend to increase, whereas the regime and distribution of precipitation show variation. Considering these results, the Western Black Sea region is at risk of global warming and has strong signals of this risk.

Keywords: Precipitation, regression model, temperature, variation trend, Western Black Sea

Cite this article as:
Bolat, İ., & Şensoy, H. (2023). Analysis of some meteorological data and their variation trends in three provinces of the western black sea region between 2012 and 2021. *Forestist*, September 19, 2023. DOI: 10.5152/forestist.2023.23005.

Corresponding Author:
İlyas Bolat
e-mail:
bolat.ilyas@hotmail.com or
ilyasbolat@bartin.edu.tr

Received: February 08, 2023
Accepted: April 17, 2023
Publication Date: September 19, 2023

Introduction

The excessive exploitation of natural resources and, thus, disturbance of the natural balance by humans have resulted in crucial problems. These problems mainly include processes such as famine, drought, extinction of species, vegetation and soil degradation, global warming and climate change, ozone depletion, and environmental pollution (Hekimoğlu & Altındeğer, 2008). In the last 10–15 years, a new problem called "global warming and climate change" has been included in the major ecological problems of humanity. The artificial heating of the atmosphere layers and the Earth's surface as a result of the human-induced increase in greenhouse gases (CO_2, CH_4, H_2O, N_2O, and CFC) and aerosols is called global warming. As a result of global warming, other climate elements (air movements, precipitation, humidity, etc.) are affected, and the rapid differentiation of the world climate in a very short period of 15-20 years, unlike long geological periods, is called global climate change. In a strict sense, this term refers to a dramatic change in the aforementioned climatic elements on the land and ocean together with the increase in temperature (Bolat & Çakıroğlu, 2022; Çepel, 2003; Türkeş, 2010). There is a consensus in almost all scientific circles and media organizations that the world is gradually warming. Therefore, one of the most significant problems of the century is global warming. It is acknowledged that the world temperature increased by 0.6 ± 0.2°C in the last century (until the end of 2000), and it has increased to 0.74 ± 0.18°C in the last hundred-year period ending in 2005. Accordingly, it is predicted 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).

Compared to precipitation, the temperature is a variable that can be measured more easily and more accurately in meteorological stations. For this reason, uncertainties arising from measurement errors are less in temperature than in precipitation. However, when determining climate change based on temperature data, small or large deviations are likely to occur due to the effect of urbanization, and so the data may show variation. The majority of the stations in Türkiye or in other countries are surrounded gradually by urban settlements and/or commercial sites. It is thus difficult to differentiate the indicators of climate change from the effects

of urbanization on temperature time series. According to the "First National Communication of Türkiye on Climate Change," maximum temperatures in the western and eastern parts of Türkiye increased in the summer months between 1951 and 2004. Similarly, minimum temperatures in summer months also had a significant increasing trend in almost all stations, which means a widespread increase in summer temperatures in Türkiye. Summer temperature series indicate an increase mostly in the western and southwestern parts of Türkiye. In addition, it is reported that there is a significant change in the amount of precipitation in both winter and autumn and that winter precipitation has decreased significantly in the western cities of Türkiye over the last five decades, while autumn precipitation has increased mostly in the northern parts of the Central Anatolia. In general, precipitation has been decreasing on the Aegean and Mediterranean coasts and increasing on the Black Sea coasts (Apak & Ubay, 2007).

According to the latest report of the Intergovernmental Panel on Climate Change (IPCC) published on August 9, 2021 (6th Assessment Report-AR6), the global temperature has been increasing much faster than anticipated. Moreover, each decade in the last 40 years has been warmer than the preceding decade since 1850. In the first two decades of the 21st century (2001–2020), the global surface temperature was 0.99°C (0.84–1.10°C) higher than in 1850–1900, and it was 1.09°C (0.95–1.20°C) higher in 2011–2020 than in 1850–1900. The increase was higher on the land [average 1.59°C (1.34–1.83°C)] than in the ocean [average 0.88°C (0.68–1.01°C)]. In addition, it is notified in the report that the temperature increase from 1850–1900 to 2010–2019 is best estimated as 1.07°C. The reason for this is claimed to be solely human activities. Therefore, possible situations that may occur in cases of temperature increases by 1.5, 2, 3, and 4°C are evaluated in the report by including four different scenarios based on different degrees of change. For example, in the most optimistic scenario with an increase of 1.5°C, it is predicted that the decline in food production, which has already reached 20% since the beginning of climate change, will accelerate and cause serious damages to food production. It is projected that more than 350 million people in urban areas will face water scarcity due to increased droughts, while coastal cities will be severely affected by rising sea levels. Furthermore, it is estimated that the global economy will have fallen by 10% by 2050. It is also believed that approximately 3 billion people will have to live under high-temperature conditions by 2070, and some parts of North Africa, the Middle East, South America, South Asia, and Australia will be affected by this situation. It is also reported that the annual average air temperature has increased between 0.95 and 3.5°C in studies about this subject and, recently, in some parts of the world (Miah et al., 2022; Tan et al., 2020). In addition, almost all these studies suggest that temperature rise has been a cause of environmental degradation and climate change. In the case of Türkiye, if the possible scenarios for temperature increase (from the most optimistic to the most pessimistic) come true, it is projected that precipitation will decrease by 10–30% across the country and the regions except for the Black Sea (at a relatively minimum level) will be affected. On the other hand, depending on the rising temperature, it is predicted that the soil will lose more moisture causing an increase in drought, especially in the Southern Aegean and Western Mediterranean regions. In this case, climate change will adversely affect the productivity and nutritional value of agricultural products. Malnutrition will cause people to suffer from various diseases and even to die. Therefore, challenging conditions are anticipated for Türkiye as the rest of the world (Daşcıoğlu, 2021; Demirbaş & Aydın, 2020; IPCC, 2021). In order to identify the regional changes in some climatic parameters within the framework of the aforementioned evaluations, the monthly minimum, average and maximum temperatures and monthly average minimum, maximum, and total annual precipitation for 2012–2021 (10-year period) recorded at the stations located in the provinces of Bartın, Zonguldak, and Düzce were examined in this study.

Methods

Locations of the Study Areas

Bartın is located in the Western Black Sea region, at the 41°53' northern latitude and 32°45' eastern longitude. It is neighbored by the Black Sea to the north, with a 59 km long coastline, Kastamonu to the east, Karabük to the east and south, and Zonguldak to the west. The altitude of the city center is 25 meters (URL–1, 2022).

Located in the Western Black Sea region of Türkiye, Zonguldak is neighbored by Bartın to the east, Karabük to the southeast, Bolu to the south, Düzce to the west, and the Black Sea to the north. Zonguldak is located at 41°27' north latitude and 31°47' east longitude (Deniz, 2015; Karanfil, 2015). Düzce is located at 39°51' north latitude and 31°08' east longitude. The Black Sea lies along the north coast of Düzce, which is neighbored by Bolu to the east and south, Sakarya to the west, and Zonguldak to the northeast. Its altitude above sea level is 160 m (URL–2, 2022) (Figure 1).

Data

The periodical data for 2012–2021 obtained from the Directorates of Bartın, Zonguldak, and Düzce Meteorological Stations of the Turkish State Meteorological Service were utilized in this study. The monthly average minimum, monthly average maximum, minimum, maximum, monthly average, and annual average temperature values, and monthly average maximum, monthly average total, and total annual precipitation values between 2012 and 2021 were calculated using the data of the three central stations carrying out synoptic or automatic observations. Annual average values were calculated as the arithmetic mean of 12 months in the calendar year. Some information about the stations is presented in Table 1, and their locations in Türkiye are shown in Figure 1.

Data Evaluation

Simple linear regression analysis was utilized to evaluate some of the temperature and precipitation data used in the study.

Results, Discussion, and Conclusions

Minimum, Average, and Maximum Temperature

In the 2012–2021 period, the lowest minimum temperature (LMnT) in Bartın was measured as −15.6°C in February 2012, and the highest minimum temperature (HMnT) as 14.9°C in July 2021 (Table 2). The average minimum temperature (AMnT) results for the other months are presented in Table 2. As it can be observed in Table 2, AMnT drops below 0°C in November and again rises above 0°C in May. Even though the month with the lowest AMnT during the evaluation period is February (−15.6°C), according to the 10-year average values of the minimum temperature, the coldest month in Bartın is January with −5.70°C and it is followed by February (−5.37°C).

In the simple linear regression model (SLRM) created using the annual AMnT values for Bartın, an increasing trend was identified in the minimum temperature ($r = .400$) (Figure 2). When the annual AMnT values are examined, it is observed that the minimum temperature never fell

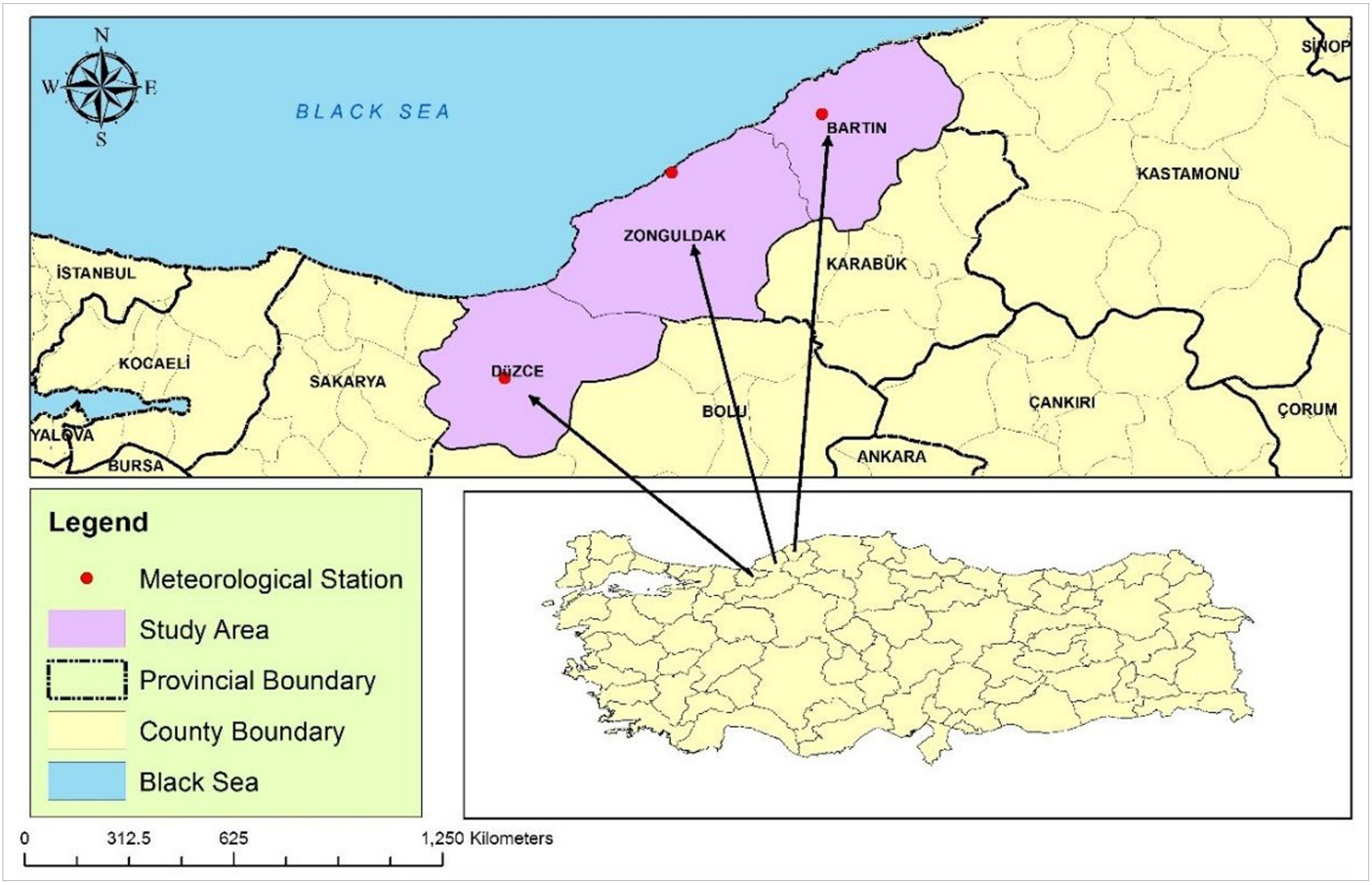

Figure 1.
Locations of the Provinces in the Scope of the Study.

Table 1.
Information on the Stations Included in the Study (URL–3, 2022)

No.	Name of Station	Altitude (m)	Latitude (North)	Longitude (East)
1	Bartın	33	41.6248	32.3569
2	Zonguldak	135	41.4492	31.7779
3	Düzce	146	40.8437	31.1488

below the average value of 2012 (1.20°C) (Figure 2). In Bartın between 2012 and 2021, AMnT was 2.53°C and the rate of increase in minimum temperature was 0.9°C.

As for the 2012–2021 period in Zonguldak, LMnT was estimated as −6.0°C in February 2012, and HMnT as 17.8°C in July 2018 and, as a quite approximate value, 17.7°C in August 2021 (Table 3). The lowest AMnT value was measured in February (−6.0°C); however, the month with the lowest average minimum temperature in Zonguldak is January with −2.01°C, and February (−1.37°C) ranks second (Table 3).

The SLRM based on the annual AMnT values for Zonguldak revealed that the minimum temperature had an increasing trend (r=.402) (Figure 3). Considering the annual AMnT values, it was identified that the minimum temperature did not fall below the average of 2012 (6.13°C), except in 2015 (5.66°C) and 2016 (5.31°C). While the annual AMnT in Zonguldak reached its highest value with 7.84°C in 2019, the average value of the decade was calculated as 6.53°C, and the rate of increase in minimum temperature was 0.31°C (Figure 3).

In Düzce between 2012 and 2021, LMnT was measured as −12.8°C in January 2021 and HMnT as 16.2°C in August 2021 (Table 4). According to the average values of minimum temperature in the 2012–2021 period, January (−7.05°C) and February (−4.28°C) are the coldest months in Düzce.

The SLRM generated using the annual AMnT values for Düzce revealed an increasing trend in the minimum temperature (r=.216) for the 2012–2021 period (Figure 4). This increasing trend is less than that in the other provinces (Bartın and Zonguldak). Based on the AMnT values, it was identified that the minimum temperature did not fall below 2.90°C, the average value of 2012, except in 2016 (2.26°C) and 2021 (2.60°C) (Figure 4). The average value of the decade was determined to be 3.72°C.

As can be observed in the graph of annual average temperature variation for Bartın (Figure 5A), the average temperature was the lowest in 2017 (13.12°C), and the highest in 2018 (14.39°C). The average temperature in Bartın between 2012 and 2021 is 13.73°C, which indicates that Bartın has the lowest average temperature among the three provinces included in the study (Figure 5B). According to the SLRM presenting the variation over the years (Figure 5A), the annual average temperature in Bartın has an increasing trend (r=.568). For the 2012–2021 period, the rate of increase in average temperature is 0.78°C, the coldest month is January (4.52°C), and the warmest month is August (23.27°C).

Table 2.
Monthly Minimum Temperature Values (°C) for Bartın from 2012 to 2021

	Months											
Years	1	2	3	4	5	6	7	8	9	10	11	12
2012	−9.3	**−15.6**	−4.9	−1.4	7.6	8.7	11.4	9.5	7.8	5.3	−0.3	−4.4
2013	−5.0	−0.6	−4.0	1.2	8.5	8.2	12.1	13.4	8.8	1.3	−1.0	−8.1
2014	−3.4	−5.3	−2.7	−1.4	6.2	10.3	13.6	14.2	6.4	1.2	−1.1	−1.5
2015	−8.4	−6.3	−1.9	−1.4	4.3	9.5	12.2	10.4	11.4	2.7	−0.2	−4.6
2016	−9.4	−4.6	−3.5	−0.2	5.0	8.0	11.8	11.6	7.7	1.6	−1.9	−8.0
2017	−7.8	−8.2	−0.5	−0.4	5.8	8.7	11.7	10.8	8.4	3.0	−0.7	−0.8
2018	−3.9	−1.8	−4.9	0.6	3.8	9.1	13.0	10.0	9.9	3.4	−1.0	−1.9
2019	−3.2	−2.1	−4.0	−0.1	5.5	12.7	11.5	10.2	5.6	7.2	−0.5	−4.0
2020	−3.6	−3.8	−4.1	−0.2	2.6	9.4	13.9	11.6	10.5	8.1	−2.1	0.0
2021	−3.0	−5.4	−3.4	0.5	2.4	8.3	**14.9**	13.3	7.7	0.6	−1.6	−9.1

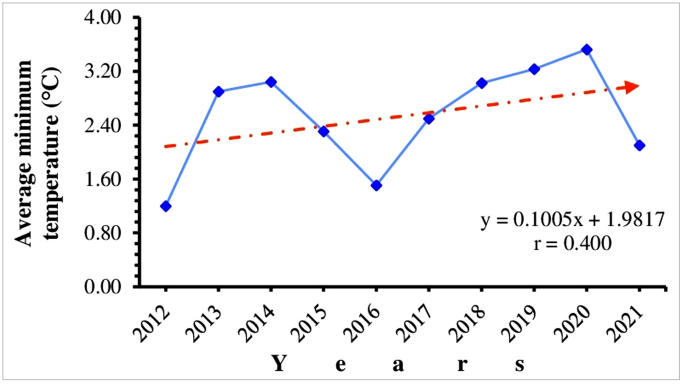

Figure 2.
Annual AMnT (°C) Values for Bartın between 2012 and 2021.
AMnT = average minimum temperature.

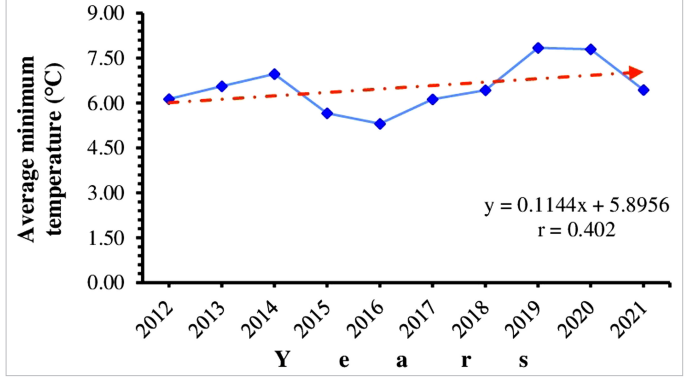

Figure 3.
Annual AMnT (°C) Values for Zonguldak between 2012 and 2021.
AMnT = average minimum temperature.

The annual average temperature variation in Zonguldak is presented in Figure 5C. The lowest average temperature was in 2015 (13.75°C), and the highest was in 2019 (15.47°C). The average temperature in Zonguldak in the 2012–2021 period is 14.70°C, so it ranks first among the three provinces (Figure 5B). According to the SLRM (Figure 5C), which presents the variation over the years within the study period, the annual average temperature in Zonguldak has an increasing trend ($r = .653$). The rate of increase in average temperature is 0.71°C,

Table 3.
Monthly Minimum Temperature Values (°C) for Zonguldak from 2012 to 2021

	Months											
Years	1	2	3	4	5	6	7	8	9	10	11	12
2012	−4.5	**−6.0**	−1.5	2.4	9.8	12.8	15.6	13.5	13.0	10.7	6.6	1.2
2013	−2.1	1.4	−0.7	4.5	10.6	14.1	15.0	**17.7**	12.4	4.0	4.3	−2.5
2014	1.1	0.8	0.4	4.8	8.6	13.8	16.4	17.0	10.7	5.8	4.3	−0.1
2015	−4.2	−3.7	−0.6	1.4	8.4	12.4	14.5	15.5	16.1	6.8	5.0	−3.7
2016	−4.2	−1.1	0.5	2.5	7.4	10.5	15.4	15.8	11.0	5.7	2.2	−2.0
2017	−4.7	−3.5	2.5	2.1	8.9	13.4	16.2	15.3	13.0	6.5	2.2	1.6
2018	−0.1	0.5	−2.1	0.2	8.0	12.6	**17.8**	16.7	11.4	6.6	5.1	0.4
2019	−0.9	1.2	0.8	4.3	9.0	15.7	16.1	15.8	11.2	11.1	6.4	3.4
2020	2.0	−2.1	0.8	3.3	7.6	11.6	17.3	16.6	15.8	12.0	4.8	3.9
2021	−2.5	−1.2	1.0	2.4	6.8	11.8	17.5	**17.7**	11.8	8.4	5.6	−2.1

Table 4.
Monthly Minimum Temperature Values (°C) for Düzce from 2012 to 2021

	Months											
Years	1	2	3	4	5	6	7	8	9	10	11	12
2012	−7.0	−12.0	−3.0	0.2	10.5	10.8	12.9	10.4	9.1	7.9	−0.7	−4.3
2013	−8.5	−0.6	−3.6	4.7	10.3	11.5	12.6	15.2	9.3	1.3	−0.2	−7.0
2014	−2.7	−5.5	−1.2	1.6	7.3	11.9	15.0	**16.2**	7.5	1.9	−0.7	−0.7
2015	−5.5	−5.6	−1.7	−0.6	7.1	10.8	13.2	13.2	14.0	3.5	0.9	−3.8
2016	−12.0	−3.6	−1.3	1.7	7.1	9.5	13.1	13.6	5.9	2.9	−1.8	−8.0
2017	−8.4	−7.3	0.6	0.0	7.2	12.3	13.5	11.2	9.0	4.6	−1.2	−2.2
2018	−3.8	−1.2	−1.2	2.8	5.9	12.9	15.5	15.0	11.7	3.6	0.9	−1.2
2019	−6.9	0.4	−1.4	1.7	7.0	14.5	12.4	13.4	5.7	7.4	2.0	−2.2
2020	−2.9	−2.5	−1.9	2.1	5.3	8.6	15.1	11.9	13.8	9.5	−1.8	1.0
2021	**−12.8**	−4.9	−1.8	0.7	4.5	8.8	15.3	14.8	9.0	2.5	−0.7	−4.2

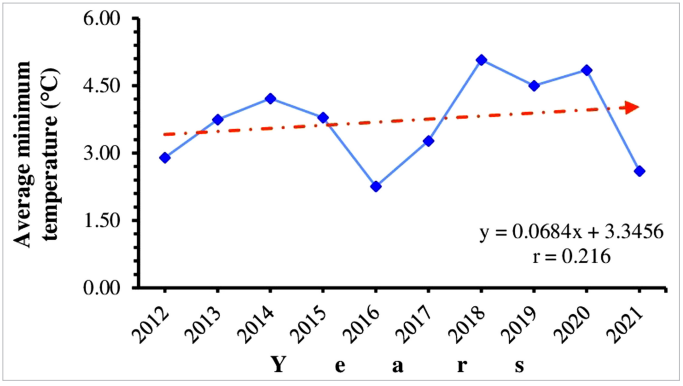

Figure 4.
Annual AMnT (°C) Values for Düzce between 2012 and 2021. AMnT = average minimum temperature.

January is the coldest (6.76°C), and August is the warmest month (23.35°C).

The annual average temperature variation in Düzce is presented in Figure 5D. The years with the lowest and highest average temperatures were 2018 (15.35°C) and 2020 (15.01°C), respectively. The average temperature in Düzce in the 2012–2021 period is 14.37°C, and it ranks second among the three provinces subject to the study (Figure 5B). The SLRM indicates an increasing trend in the annual average temperature in Düzce ($r = .584$) (Figure 5D). The rate of increase in average temperature over the 10-year period is 0.47°C, January is the coldest (4.76°C), and August is the warmest month (23.84°C).

The lowest maximum temperature (LMxT) in Bartın between 2012 and 2021 was estimated as 15.8°C in December 2016, and the highest maximum temperature (HMxT) was 40.5°C in September 2017 (Table 5). Even though the monthly average maximum temperature (AMxT) was

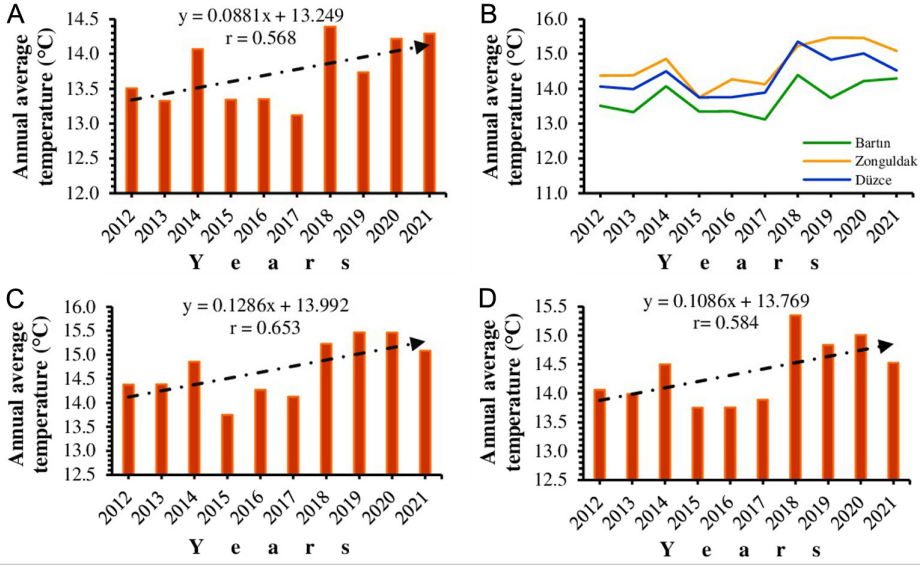

Figure 5.
Annual Average Temperature Variation in Bartın (A) Province, Comparison with Other Provinces (B), Annual Average Temperature Variation in Zonguldak (C) and Düzce (D) Provinces.

Table 5.
Monthly Maximum Temperature (°C) Values for Bartın from 2012 to 2021

	Months											
Years	1	2	3	4	5	6	7	8	9	10	11	12
2012	17.3	17.6	21.9	33.4	29.5	35.3	35.9	34.2	34.8	31.7	26.4	22.4
2013	22.2	23.0	31.6	29.8	34.9	32.1	32.5	32.7	33.4	26.2	24.6	19.2
2014	19.7	23.7	23.7	27.9	31.6	31.3	38.2	33.8	29.8	26.8	23.8	19.9
2015	20.9	23.7	25.3	27.2	33.1	31.2	36.1	32.5	37.8	26.7	24.4	17.1
2016	21.9	26.9	28.4	32.3	29.8	35.7	35.4	37.7	33.1	28.9	27.7	**15.8**
2017	19.4	21.6	25.2	27.2	30.9	34.6	35.5	31.1	**40.5**	27.9	21.5	24.8
2018	17.9	20.9	28.2	29.3	31.3	32.3	32.9	32.7	33.2	25.8	25	16.2
2019	20.3	21.1	23.1	26.3	35.4	30.5	31.6	34.3	31.2	30.8	28.9	22.3
2020	16.7	26.2	29.4	26.9	35.4	33.0	32.8	37.8	34.0	35.5	21.1	22.9
2021	23.2	25.0	24.3	28.9	34.7	34.3	37.4	39.6	33.9	32.0	30.6	25.4

the highest in September (40.5°C), according to the 10-year average values, July is the warmest month in Bartın, with 34.83°C. In the ranking of the warmest months, August (34.64°C) is the second, and September (34.17°C) is the third.

According to the SLRM based on the annual AMxT values for Bartın, an increasing trend was identified in the maximum temperature ($r = .447$) (Figure 6). The rate of increase in the maximum temperature in Bartın between 2012 and 2021 was 2.41°C, and the 10-year average was 28.54°C. It is observed that the maximum temperature was above average in 2016, 2020, and 2021 (Figure 6). The years in which the maximum temperature increased the most with an increase by 1.47°C were 2016 and 2021, respectively.

In Zonguldak, in the period of 2012–2021, LMxT was estimated as 13.4°C in December 2015 and HMxT as 36.2 C in September 2017 (Table 6). Between 2012 and 2021, the highest monthly AMxT was measured in September (36.2°C), which is also the warmest month in Zonguldak, with 30.36°C as indicated by the 10-year average values of maximum temperature. Among the warmest months, July (29.84°C) ranks second, and August (29.82°C) ranks third.

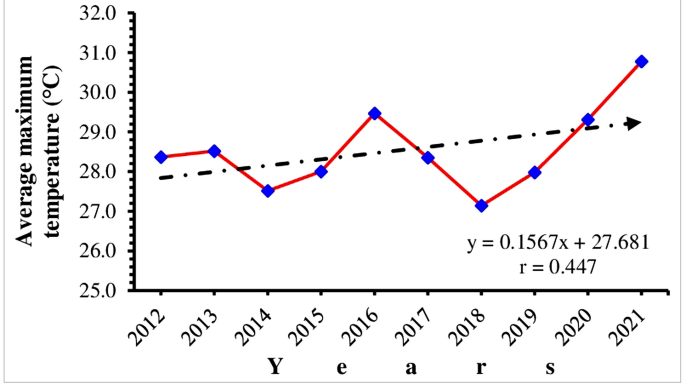

Figure 6.
Annual AMxT (°C) Values for Bartın between 2012 and 2021. AMxT = average maximum temperature.

The SLRM created using the annual AMxT values for Zonguldak revealed an increasing trend in the maximum temperature in the 2012–2021 period ($r = .421$) (Figure 7). The rate of increase in the maximum temperature during the study period was 1.23°C. Considering the AMxT

Table 6.
Monthly Maximum Temperature (°C) Values for Zonguldak from 2012 to 2021

	Months											
Years	1	2	3	4	5	6	7	8	9	10	11	12
2012	16.7	13.5	18.4	31.8	27.7	30.0	29.1	31.4	28.8	28.5	24.5	23.4
2013	21.2	21.7	27.7	25.5	33.2	27.4	28.4	28.5	30.2	23.7	23.2	18.0
2014	20.7	18.3	21.5	23.2	28.4	29.8	32.9	28.7	26.6	26.0	21.0	21.1
2015	18.9	23.4	20.4	23.2	26.6	28.2	30.8	28.0	33.9	24.7	23.2	**13.4**
2016	20.1	24.7	24.0	29.7	27.1	30.5	26.8	34.4	30.8	27.0	29.1	14.7
2017	18.2	20.9	21.4	25.0	29.5	35.2	30.6	29.5	**36.2**	25.9	24.5	23.2
2018	16.1	22.3	27.4	27.5	28.7	28.7	30.9	29.7	28.1	24.1	23.1	19.0
2019	18.3	19.8	21.2	23.8	32.0	28.2	29.8	28.3	28.9	27.4	26.2	21.6
2020	16.6	21.8	26.9	23.5	34.5	29.7	29.0	27.8	30.7	30.2	17.4	20.1
2021	23.9	23.9	18.8	24.5	31.3	28.6	30.1	31.9	29.4	23.8	29.6	22.7

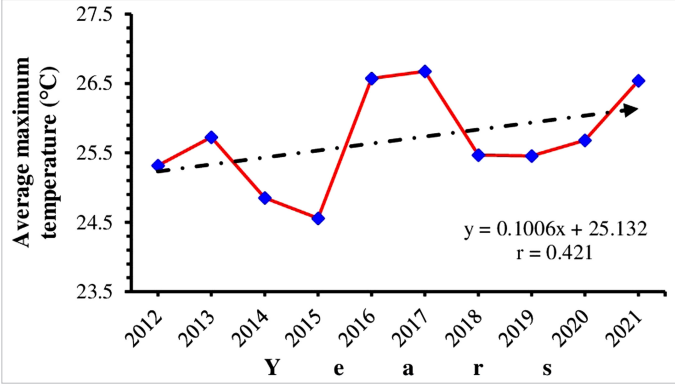

Figure 7.
Annual AMxT (°C) Values for Zonguldak between 2012 and 2021. AMxT = average maximum temperature.

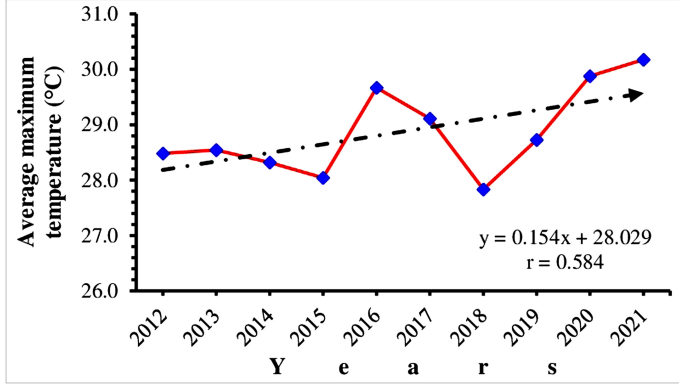

Figure 8.
Annual AMxT (°C) Values for Düzce between 2012 and 2021. AMxT = average maximum temperature.

values, it was identified that the maximum temperature did not fall below the average value of 2012 (25.32°C), except in 2014 (24.85°C) and 2015 (24.56°C). The 10-year average of the maximum temperature was 25.69°C, and the highest increase was in 2016 at 2.02°C.

In Düzce in the period of 2012–2021, LMxT was estimated as 13.5°C in December 2015 and HMxT as 39.7°C in August 2021 (Table 7). Even though the highest AMxT was measured in August, the 10-year maximum temperature average indicates that July is the warmest month in Düzce, with 35.75°C, and August (35.52°C) ranks second.

According to the SLRM generated using the annual AMxT values for Düzce, the maximum temperature had an increasing trend ($r = .584$) (Figure 8). The rate of increase in maximum temperature for Düzce was 1.69°C, and it was identified that the maximum temperature did not fall below the average value of 2012 (28.48°C) except in 2014 (28.32°C), 2015 (28.04°C) and 2018 (27.83°C). The AMxT during the study period was 28.88°C, and the year in which the maximum temperature increased the most was 2016 with 1.63°C.

It is emphasized that in Türkiye, with significant increases in minimum (nighttime) temperatures, the nighttime warming rates are in the range of 0.08–0.56°C/per decade (Türkeş et al., 2002). In Türkiye, over the last 25 years, the temperature regime has evolved significantly to milder and warmer conditions, and there have been significant changes in the frequency and intensity of heat waves (Türkeş, 2019). The average temperature in Türkiye between 2010 and 2020 was 14.1°C. According to long-term data, however, the average temperature between 1970 and 2020 was 13.2°C. Furthermore, it is reported in the same study that the annual average temperature in Türkiye had an increasing trend in the 1970–2020 period (URL–4, 2022). In another study, it is noted that the lowest nighttime and highest daytime temperatures in Türkiye have tended to increase, especially starting from the 1990s (Türkeş, 2012). Among the average temperature values obtained in this study, only that of Bartın (13.73°C) is below the average of Türkiye, whereas those of the other two provinces are above the overall average. In this study, an increasing trend in the annual average temperature was identified in Bartın, Zonguldak, and Düzce between 2012 and 2021. In the study conducted by Şensoy and Ateşoğlu (2018), the average annual temperature value in Bartın between 1965 and 2014 was estimated as 12.74°C. When this value is compared with the average temperature value obtained in this study (13.73°C), it is observed that the average temperature in Bartın has been approximately 0.99°C higher in the last decade. Based on the data of the Bartın meteorological station, Öztürk et al. (2016) indicated that the average annual temperature of the preceding 11 years (2002–2012) had been 0.7°C higher than that of the years

Table 7.
Monthly Maximum Temperature (°C) Values for Düzce from 2012 to 2021

	Months											
Years	1	2	3	4	5	6	7	8	9	10	11	12
2012	16.4	16.8	22.2	31.5	30.5	36.1	35.9	36.7	34.3	31.3	28.1	22.0
2013	21.2	22.5	29.6	30.2	35.8	34.4	33.4	35.3	34.7	26.2	25.0	14.2
2014	21.2	24.4	24.3	26.2	31.5	35.8	38.9	34.5	31.0	26.6	23.4	22.0
2015	18.9	23.7	24.6	29.3	31.8	32.3	37.8	34.3	37.9	27.8	24.6	**13.5**
2016	23.0	26.9	30.5	32.3	31.4	35.3	36.5	35.6	34.6	30.2	26.7	13.0
2017	16.9	23.8	24.4	29.6	33.3	36.7	36.1	340.	38.7	27.5	23.2	25.1
2018	18.0	22.9	25.8	29.0	32.8	33.4	34.2	34.1	34.1	29.1	24.5	16.1
2019	20.0	22.6	24.7	29.2	34.1	31.6	33.6	33.6	330.	32.9	28.2	21.2
2020	17.1	26.2	28.6	28.1	39.5	34.0	34.6	37.4	35.2	36.3	20.0	21.5
2021	26.1	24.6	22.8	30.4	33.7	33.6	36.5	**39.7**	32.9	29.8	28.7	23.3

between 1982 and 2001, confirming the overall findings of this study for the Bartın Province. The authors (Öztürk et al., 2016) expressed this 0.7°C temperature increase as the silent climate warming. According to the study by Öztürk et al. (2017), any possibility of climate change in the Western Black Sea region would have threatened the agricultural diversity within the region. Şensoy and Ateşoğlu (2018) also state that the average annual and summer temperatures were 1.8°C and 2.06°C higher, respectively, in the last two decades of the 1965–2014 period. In another similar study, it is indicated that there are monthly variations in average minimum and average maximum temperatures and minimum and maximum temperatures in Bartın, Zonguldak, and Düzce between 1980–1999 and 2000–2015 (Bolat et al., 2018). In the relevant study, it was also identified that both AMnT and AMxT values relatively increased between 1980–1999 and 2000–2015. The results obtained in this study are consistent with those of previous studies. In a study covering the years 1965–2015 in Bartın (Yaman & Ertuğrul, 2020), it is reported that especially summer temperatures have an increasing trend of .001 significance and that the potential of the maximum temperature to change by 0.55°C every 10 years should be taken into consideration in the next period's management plans for agriculture, forest, and natural resources including water. According to a recent study by Türkeş (2019), Türkiye has an increasing trend, especially in summer and autumn temperatures, and this warming is gradually getting stronger. However, it is also specified that this warming is relatively weak throughout the Black Sea region compared to the other regions. The results of a study covering Kastamonu, Karabük, and Bolu provinces indicate that there are significant increases in minimum and maximum temperatures on a monthly basis. On the other hand, an increasing trend was determined in the monthly and annual average temperature data of Kastamonu, Karabük, and Bolu provinces, especially in summer (Bolat et al., 2017). In a study conducted by Demir et al. (2008), it was identified that there was an overall increasing trend in the minimum temperatures in 27 stations across Türkiye, and the annual maximum temperature series tended to increase in the Mediterranean, Southeastern Anatolia regions, and the southern parts of Eastern Anatolia. For example, when the long-term trend of maximum temperatures was investigated by Cosun and Karabulut (2009), increases in maximum temperatures were discovered in the confidence interval of 95% in Kahramanmaraş and 90% in Afşin. In addition, the increases in minimum temperatures were found to be more significant than those in maximum temperatures. Slightly different from these evaluations, Ay (2020) stated that the *z* values calculated in the provinces of the Western Black Sea region of Türkiye (Bartın, Bolu, Düzce, Kastamonu, Sinop and Zonguldak) in the 1960–2017 period did not show a statistically significant trend and that there were statistically nonsignificant trends in the monthly average temperature time series. Considering the Mann–Kendall test, the increasing trends in all the provinces were not statistically significant.

Minimum, Maximum, and Average Precipitation Values

The total monthly precipitation (TMP) in Bartın between 2012 and 2021 is presented in Table 8. The lowest amount of precipitation (LAP) measured was 1.9 mm in August 2020, and the highest amount of precipitation (HAP) was 294.8 mm in January 2016. The seasonal distribution of TMP in descending order is winter (380.81 mm), autumn (285.75 mm), spring (218.17 mm), and summer (202.29 mm).

The total annual precipitation (TAP) variation in Bartın is presented in Figure 9A. The lowest TAP (842.20 mm) was in 2020, and the highest (1369.60 mm) was in 2021. The average total precipitation (AvTP) in Bartın in the period of 2012–2021 was 1087.02 mm, which indicates that Bartın ranks second among the three provinces included in the study (Figure 9B). On the other hand, the SLRM created with the distribution of TAP (Figure 9A) revealed that the amount of precipitation in Bartın had a decreasing trend ($r = -.081$).

TMP in Zonguldak for the 2012–2021 period is presented in Table 9. Lowest amount of precipitation was measured as 0.8 mm in August 2020 and HAP as 283.4 mm in December 2021. The seasonal distribution of TMP is winter (445.99 mm), autumn (331.79 mm), spring (240.42 mm), and summer (221.16 mm), respectively.

The TAP variation in Zonguldak is presented in Figure 9C. No precipitation was measured in May 2013. The lowest TAP (1047.40 mm) was recorded in 2020, and the highest (1664.50 mm) in 2021. AvTP in Zonguldak was 1239.36 mm for the period of 2012–2021. According to this result, Zonguldak ranks first among the three provinces (Figure 9B). Considering the SLRM created using the distribution of TAP, an increasing trend was identified in the precipitation in Zonguldak ($r = .423$) (Figure 9C).

TMP in Düzce between 2012 and 2021 is presented in Table 10. No precipitation was measured in August 2020. Lowest amount of precipitation was recorded as 0.4 mm in September 2012. Since the difference in total precipitation between 2012 and 2020 was only 0.4 mm, these

Table 8.
Total Monthly Precipitation (mm) in Bartın from 2012 to 2021

	Months											
Years	1	2	3	4	5	6	7	8	9	10	11	12
2012	182.1	146.2	138	31.2	37.4	22.4	71.7	172.5	20.9	47.7	46.8	175.6
2013	176.6	50.9	124.1	39.2	5.8	66.6	39.6	14.4	137.6	265.3	56.1	130.2
2014	32.1	52.0	67.6	44.2	91.1	141.2	146.3	50.9	123.6	80.9	121.3	115.7
2015	132.5	107.4	77.7	77.3	79.2	118.6	31.0	18.0	13.6	273.0	63.3	84.0
2016	**294.8**	126.8	43.0	63.9	103.8	44.8	18.4	187	105.3	81.8	114.8	165.9
2017	117.2	54.0	72.2	84.1	98.2	67.4	18.7	76.3	23.4	122.9	158.0	164.4
2018	77.7	59.5	170.7	17.3	58.4	102.2	27.7	5.9	147.1	97.3	62.3	218.9
2019	132.9	56.3	34.5	65.7	91.6	43.4	73.8	68.8	29.5	83.9	31.4	153.1
2020	120.9	139.7	38.5	32.1	87.0	49.7	56.4	**1.9**	76.1	91.0	120.2	28.7
2021	240.2	79.3	139.3	98.7	69.9	131.7	103.0	52.6	89.5	79.2	93.7	192.5

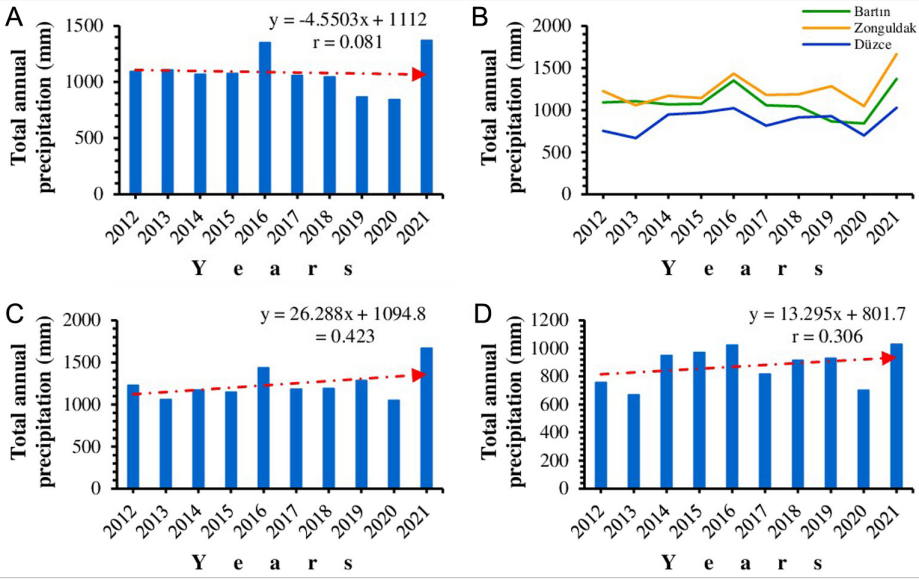

Figure 9.
Annual Average Precipitation Variation in Bartın (A) Province, Comparison with Other Provinces (B), Annual Average Precipitation Variation in Zonguldak (C) and Düzce (D) Provinces.

Table 9.
Total Monthly Precipitation (mm) in Zonguldak from 2012 to 2021

	Months											
Years	1	2	3	4	5	6	7	8	9	10	11	12
2012	239.2	164.5	139.3	45.0	51.8	59.7	31.2	130.0	33.8	17.3	105.9	206.5
2013	141.3	75.7	101.7	53.5	**0.0**	16.6	52.5	19.5	109.2	324.2	47.1	116.4
2014	44.4	51.1	97.2	38.8	103.9	107.2	149.6	58.8	132.8	62.4	131.6	193.8
2015	170.4	164.4	64.0	114.1	60.9	110.7	25.7	10.6	81.1	240.8	39.9	59.50
2016	199.7	104.6	59.8	60.4	109.8	55.7	13.9	133.8	184.9	99.5	197.2	214.4
2017	103.8	38.6	86.2	90.9	83.4	135.3	30.0	113.6	45.1	123.1	118.7	211.8
2018	83.9	95.8	165.8	15.3	75.0	32.6	77.6	9.9	127.6	93.2	133.4	277.4
2019	133.3	119.4	35.3	66.6	96.3	65.8	183.8	160.9	43.7	105.1	31.9	242.3
2020	141.1	139.2	52.6	36.2	92.1	80.9	89.2	**0.8**	50.9	174.5	111.7	78.20
2021	257.2	108.6	202.2	128.4	77.7	152.8	53.9	49.0	126.1	110.0	115.2	**283.4**

2 years were considered as the years with the LAP. On the other hand, 216.6 mm measured in January 2016 was determined as HAP. The seasonal distribution of TMP is winter (271.14 mm), spring (222.37 mm), summer (202.85 mm), and autumn (183.52 mm), respectively.

The TAP variation in Düzce is presented in Figure 9D. The year with the lowest amount of TAP was 2013 (667.80 mm), and the highest years were 2021 (1027.50 mm) and 2016 (1022.90 mm), respectively. AvTP in Düzce was estimated as 874.82 mm in the 2012–2021 period. Düzce has the least amount of precipitation among the three provinces (Figure 9B). The SLRM based on the TAP distribution revealed an increasing trend in the precipitation in Düzce ($r = .306$) (Figure 9D).

It is reported that the TAP average in Türkiye was 621.4 mm between 1970 and 2020 and 619.3 mm between 2010 and 2020 (URL–5, 2022). Even though the average annual precipitation in the Western Black Sea region is 1400 mm, the precipitation regime is not homogeneous (Kayhan, 2007). Total amounts of precipitation in Bartın, Zonguldak, and Düzce are 30–50% higher than the average of Türkiye (621.4 mm). Nonetheless, the annual average precipitation of the three provinces is less than the average of the Western Black Sea region (1400 mm). According to these findings, the highest precipitation was in Zonguldak, and the lowest was in Düzce between 2012 and 2021. This result shows that even neighboring provinces may not have equal amount of precipitation at an equal rate, and variations may occur. According to the SLRM, it was identified in this study that the amount of TAP had a decreasing trend in Bartın and an increasing trend in Zonguldak and Düzce. Conversely, in a study evaluating the annual AvTP in the 1980–1999 and 2000–2015 periods, it was discovered that the precipitation increased by 24.0 mm in Bartın and decreased by 48.0–60.0 mm in Zonguldak and Düzce (Bolat et al., 2018). In a study by Ay (2020) covering the years 1960–2017 in the provinces of the Western Black Sea region of Türkiye (Bartın, Bolu, Düzce, Kastamonu, Sinop, and Zonguldak), it is stated that the amount of TMP in Zonguldak and Düzce

Table 10.
Total Monthly Precipitation (mm) in Düzce from 2012 to 2021

	Months											
Years	1	2	3	4	5	6	7	8	9	10	11	12
2012	59.1	119.1	84.6	39.6	74.6	38.4	23.1	90.6	**0.4**	51.1	44.8	129.5
2013	106.2	56.5	77.3	64.1	16.4	43.0	12.2	5.6	28.0	158.2	39.1	61.2
2014	27.0	21.6	75.8	37.7	102.1	134.7	81.8	88.8	138.0	46.5	67.1	127.7
2015	182.9	112.3	42.4	114.8	72.0	111.1	6.6	11.4	40.0	201.0	28.0	47.2
2016	**216.6**	96.6	66.2	47.8	139.9	65.6	19.2	60.5	65.8	31.0	66.9	146.8
2017	58.3	31.0	50.0	81.6	60.8	113.5	28.2	53.2	24.0	109.4	72.2	133.8
2018	61.8	51.4	128.4	34.8	122.4	107.8	73.6	19.8	82.2	72.3	47.6	111.6
2019	92.4	71.0	36.2	74.6	114.8	133.6	81.3	93.6	18.2	46.0	26.4	139.2
2020	82.2	103.5	68.2	39.6	66.4	184.7	21.8	**0.0**	25.2	58.8	22.2	27.0
2021	129.4	36.0	97.8	100.0	92.8	99.4	143.2	31.6	100.8	62.8	61.2	72.5

does not have a statistically significant trend according to the *z*-score calculated, yet there are statistically nonsignificant trends according to the sign of *z*-score. Considering the results of the Mann-Kendall test, Bolu, Düzce, and Zonguldak have a nonsignificant decreasing trend, while Bartın, Kastamonu, and Sinop have a nonsignificant increasing trend. In a study examining the variation in annual average precipitation in Bartın over the 1965–2014 period, the precipitation increased by 52.95 mm in the last two decades of the relevant period (Şensoy & Ateşoğlu, 2018). While previous studies indicated an increasing trend in the TAP in Bartın, a decreasing trend was identified in this study. This may result from the different study periods and the fact that the TAP in Bartın was around 850 mm, especially in 2019 and 2020. On the other hand, according to a study covering the 1965–2015 period, no significant variation trend was identified in monthly, seasonal and annual precipitation in Bartın (Yaman & Ertuğrul, 2020). However, when the long-term trends and variations in Türkiye are examined, it is observed that the Mediterranean regime is mostly dominant in winter and spring precipitation, and that there is a significant decrease in the Marmara, Aegean, Mediterranean, Southeastern Anatolia regions, and some parts of the Central and Eastern Anatolia. For example, the cumulative precipitation for Türkiye calculated between October 1, 2013, and January 17, 2014, decreased by 37.0% compared to the long-term average and by 47.4% compared to that of 2013 (Türkeş, 2019). Nevertheless, it is noted in the same study that the seasonal and annual precipitation trends observed in Türkiye are not as strong as the trends observed in temperatures. Türkeş (2019) states that the variations in precipitation are not in the form of long-term trends, but in the form of changes and fluctuations, yet there are significant differences identified in the frequency and size of the dry-humid periods. In addition, it is noted that the areal precipitation variations are also strong. This drying trend mostly affects the Aegean, Mediterranean, Marmara, and Central and Southeastern Anatolia regions in Türkiye; it is not foreseen for the Western Black Sea region in the near future. Considering the TAP, this study also reveals similar results and is consistent with previous evaluations of precipitation trends and variations conducted for Türkiye.

When the minimum, average, and maximum temperature variations over the 2012–2021 period for the three provinces subject to this study are examined, it is observed that the temperatures have an increasing trend. According to the regression model, the highest increase in both minimum ($r = .402$) and average ($r = .653$) temperatures is in Zonguldak, whereas the highest increase in maximum temperature ($r = .584$) is in Düzce. Considering the minimum and average temperature values for all three provinces, the coldest month is January, and the warmest month is August. However, according to the AMxT values between 2012 and 2021, the warmest month is July in Bartın and Düzce and September in Zonguldak. It is observed that the annual AMxT values have started to increase in all three provinces, especially after 2018. While the minimum precipitation was generally measured in August in all three provinces, the maximum precipitation was measured in December (Zonguldak; 283.4 mm) and January (Bartın; 294.8 mm and Düzce; 216.6 mm). The AvTP was determined as 1087.02 mm in Bartın, 1239.36 mm in Zonguldak, and 874.82 mm in Düzce. The regression analysis performed to identify the AvTP variation by years has revealed that the AvTP has a decreasing trend ($r = -.081$) in Bartın yet an increasing trend in Zonguldak ($r = .423$) and Düzce ($r = .306$). According to these results, the highest significant increase in AvTP is in Zonguldak.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – İ.B.; Design – İ.B., H.Ş.; Supervision – İ.B., H.Ş.; Resources – İ.B.; Materials – İ.B., H.Ş.; Data Collection and/or Processing – İ.B.; Analysis and/or Interpretation – İ.B., H.Ş.; Literature Search – İ.B., H.Ş.; Writing Manuscript – İ.B.; Critical Review – İ.B., H.Ş.; Other – İ.B.

Acknowledgment: We would like to express our gratitude to the Directorate of Bartın Meteorological Station of Turkish State Meteorological Service of the Republic of Türkiye Ministry of Environment, Urbanization, and Climate Change, where we obtained the meteorological data (for the 2012–2021 period) used in the study.

Declaration of Interests: The authors have no conflict of interest to declare.

Funding: The authors declared that this study has received no financial support.

References

- Apak, G., & Ubay, B. (2007). *First national communication of Turkey on climate change*. http://www.tr.undp.org/content/dam/turkey/docs/Publications/EnvSust/iklim1.bildirimi-27ocak2007.pdf
- Ay, M. (2020). Trend and homogeneity analysis in temperature and rainfall series in the western Black Sea region, Turkey. *Theoretical and Applied Climatology*, *139*(3–4), 837–848. [CrossRef]
- Bolat, İ., & Çakıroğlu, K. (2022). İklim Değişimi ile Toprak Organik Maddesi ve Toprak Sağlığı Arasındaki İlişkiler, Bölüm. In G. Yayınevi (Ed.), *Ziraat & orman, su Ürünlerinde araştırma ve Değerlendirmeler* (pp. 159–184). Gece Yayınevi.

- Bolat, İ., Kara, Ö., & Tok, E. (2017). Change of temperature and precipitation in Kastamonu, Karabük and Bolu between 1980–1999 and 2000–2015 years. *Journal of Bartin Faculty of Forestry*, *19*(1), 276–289.
- Bolat, İ., Kara, Ö., & Tok, E. (2018). Global warming and climate change: A practical study on Bartın, Zonguldak and Düzce. *Journal of Bartın Faculty of Forestry*, *20*(1), 116–127.
- Çepel, N. (2003). *Ekolojik sorunlar ve Çözümleri. TÜBİTAK, popüler bilim kitapları*. Aydoğdu Matbaası.
- Cosun, F., & Karabulut, M. (2009). Kahramanmaraş'ta ortalama [minimum ve maksimum sıcaklıkların trend analizi]. *Türk Coğrafya Dergisi*, *53*, 41–50.
- Daşcıoğlu, B. Z. Ö. (2021). Ipcc'nin altıncı değerlendirme raporu ne anlama geliyor? *Seta-Perspektif*, *136*, 1–4.
- Demir, İ., Kılıç, G., Coşkun, M., & Sümer, U. M. (2008). *Türkiye'de maksimum, minimum ve ortalama hava sıcaklıkları ile yağış dizilerinde gözlenen değişiklikler ve eğilimler*. TMMOB İklim Değişimi sempozyumu, Bildiriler kitabı, 69–84. TMMOB adına TMMOB Meteoroloji Mühendisleri Odası, Ankara.
- Demirbaş, M., & Aydın, D. (2020). 21. Yüzyılın en büyük tehdidi: Küresel İklim değişikliği. *Ecological Life Sciences (NWSAELS)*, *15*(4), 163–179. [CrossRef]
- Deniz, T. (2015). Zonguldak İlinde Nüfusun Gelişimi ve Dağılışı. *Doğu Coğrafya Dergisi*, *19*(32), 299–320. [CrossRef]
- Hekimoğlu, B., & Altındeğer, M. (2008). *Küresel Isınma ve İklim değişikliği*. T.C. Samsun Valiliği il tarım Müdürlüğü.
- IPCC. (2001). *Intergovernmental Panel on Climate Change, the scientific basis, contribution of working group I to the third assessment report of the Intergovernmental Panel on Climate Change* J. T. Houghton, et al. (Eds.). Cambridge University Press.
- IPCC. (2021). *"Summary for Policymakers", Climate Change 2021: The Physical Science Basis, Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Valerie Masson-Delmotte vd*. Cambridge University Press.
- Karanfil, K. C. (2015). *Batı Karadeniz bölgesi huni örümcek faunası ve sistematiği (Araneae: Agelenidae)*. Kırıkkale Üniversitesi. Fen Bilimleri Enstitüsü, Biyoloji Anabilim Dalı Yüksek Lisans Tezi.
- Kayhan, M. (2007). *Küresel iklim değişikliği ve Türkiye. I. Türkiye İklim Değişikliği Kongresi Bildiri Özetleri Kitabı, TİKDEK 2007*. İTÜ.
- Miah, M. D., Hasnat, G. N. T., Nath, B., Saeem, M. G. U., & Rahman, M. M. (2022). Spatial and temporal changes in the urban green spaces and land surface temperature in the Chittagong city corporation of Bangladesh between 2000 and 2020. *Forestist*, 2022.22013. [CrossRef]
- Murat, T. (2012). Türkiye'de gözlenen ve Öngörülen İklim değişikliği, kuraklık ve Çölleşme. *Ankara Üniversitesi Çevrebilimleri Dergisi*, *4*(2), 1–32. [CrossRef]
- Öztürk, M., Bolat, İ., & Gökyer, E. (2017). Land use suitability classification for the actual agricultural areas within the Bartın stream watershed of Turkey. *Periodicals of Engineering and Natural Sciences*, *5*(1). [CrossRef]
- Öztürk, M., Bolat, İ., Gökyer, E., & Kara, Ö. (2016). Growth gradients of multi-aged pure oriental beech stands along the altitudinal gradients within a mesoscale watershed landscape. *Applied Ecology and Environmental Research*, *14*(4), 101–119. [CrossRef]
- Sağlam, N. E., Düzgüneş, E., & Balık, İ. (2008). Küresel Isınma ve İklim değişikliği. *Su Ürünleri Dergisi*, *25*(1), 89–94.
- Sarıyıldız, T., Varan, S., & Duman, A. (2008). Ölü örtü ayrışma oranları üzerinde kimyasal bileşenlerin ve yetişme ortamı özelliklerinin etkisi: Artvin ve Ankara yöresine ait örnek bir çalışma. *Kastamonu Orman Fakültesi Dergisi*, *8*(2), 109–119.
- Şensoy, H., & Ateşoğlu, A. (2018). Bartın Yöresinde İklim tipi değişikliğine yönelik bir değerlendirme. *Bartın Orman Fakültesi Dergisi*, *20*(3), 576–582.
- Tan, J., Yu, D., Li, Q., Tan, X., & Zhou, W. (2020). Spatial relationship between land-use/land-cover change and land surface temperature in the Dongting Lake area, China. *Scientific Reports*, *10*(1), 9245. [CrossRef]
- Türkeş, M. (2010). *Klimatoloji ve meteoroloji*. Kriter Yayınevi.
- Türkeş, M. (2019). *Scientific basis of climate change and impacts on Turkey. Climate change training module series 1, the project co-funded by the European Union and the Republic of Turkey*. http://www.iklimin.org/moduller/bilimmodulu.pdf [access: 24.12.2022]
- Türkeş, M., Sümer, U., & Demir, İ. (2002). Türkiye'nin Günlük ortalama maksimum ve minimum Hava Sıcaklıkları Ile sıcaklık Genişliğindeki eğilimler ve değişiklikler. *Klimatoloji Çalıştayı*, *11–13*, 89–106.
- URL–1. (2022). http://www.bartintso.org.tr, Bartın Ticaret ve Sanayi Odası web sayfası, (Erişim tarihi: 10.03.2022).
- URL–2. (2022). http://www.duzce.bel.tr, Düzce Belediyesi web sayfası, (Erişim tarihi: 10.03.2022).
- URL–3. (2022). https://www.mgm.gov.tr/tahmin/il-ve-ilceler.aspx?il, Meteoroloji Genel Müdürlüğü web sayfası, (Erişim tarihi: 10.03.2022).
- URL–4. (2022). https://www.mgm.gov.tr/FILES/resmi-istatistikler/parametreAnalizi/Turkiye-Ortalama-Sicaklik-2020.pdf, Meteoroloji Genel Müdürlüğü web sayfası, (Erişim tarihi: 10.03.2022).
- URL–5. (2022). https://www.mgm.gov.tr/FILES/resmi-istatistikler/parametreAnalizi/Turkiye-Yagis-2020.pdf, Meteoroloji Genel Müdürlüğü web sayfası, (Erişim tarihi: 10.03.2022).
- Yaman, B., & Ertuğrul, M. (2020). Change-point detection and trend analysis in monthly, seasonal and annual air temperature and precipitation series in Bartın province in the western Black Sea region of Turkey. *Geology, Geophysics and Environment*, *46*(3), 223–223. [CrossRef]