# Warsaw University of Technology

Faculty of Building Services, Hydro and Environmental Engineering

## Applied Climatology

## Climatological Analysis for Ataturk Airport in Istanbul

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# Climatologically Analysis of Istanbul Ataturk Airport (1990 – 2020)

The aim of this study is to make a 30-years climate analysis for Istanbul Ataturk Airport by evaluating the temperature and precipitation data from 1990 to 2020.

1. **Location information Site Description for Istanbul Ataturk Airport**

Istanbul Ataturk Airport has served national and international flights since 1953 until 6 April 2019. Ataturk Airport offers millions of flights with three runways called "05/23" with a width of 60 meters and a length of 2 thousand 600 meters, "17 L/35 R" with a length of 45 meters and a length of 3 thousand meters, and "17R/35L" with a length of 45 meters and a length of 3 thousand meters. With the opening of the Istanbul airport, Ataturk airport was closed to passenger flights, and today it is only used for cargo flights.



**Figure 1: Location of Ataturk Airport on Turkey**



**Figure 2:  Ataturk Airport**

Coordinates: N40°58.57' / E28°48.85'
Elevation:  33m
Station name & code: Atatürk Airport & LTBA
Country: Turkey

## 2. Data and Methods

Data were obtained from GSOD (link) database and processes using R language and Climate KNMI Explorer were used as a tool. Data sets from CRU TS 4.05 (land)- 0.5°(Observation) and ERA5 (Reanalyses) databases were used.
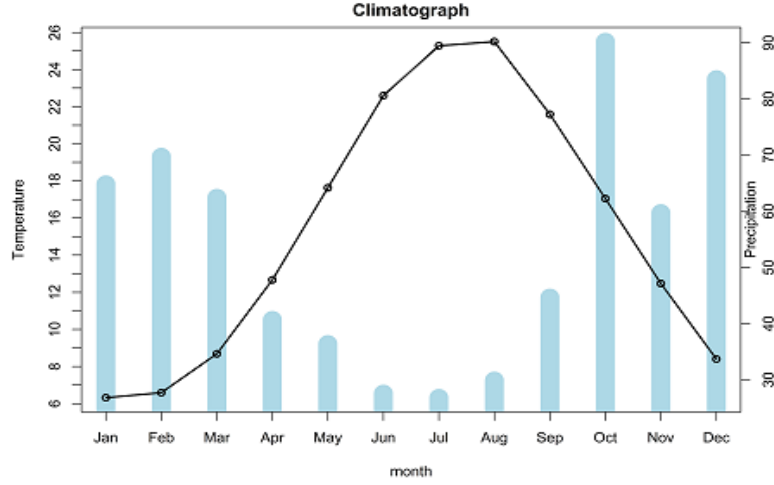


Figure 2 Climatograph for Atatürk Airport

Istanbul Ataturk Airport is at 40°58.57' north latitude. Since it is located in the middle latitude, it is considered in the C class according to the Koppen classification.

Looking at the amount of precipitation in the climatograph, it is clear that while the summers are dry, the winters are rainy. According to Koppen classification, it can be evaluated in the **'s'** class in terms of precipitation and drought.

When we look at the temperature change in the climatograph, it is clear that the summers are hot and dry. According to the Koppen classification, it is in the **'a'** class in terms of temperature difference.

As a result, Istanbul is in the **'Csa'** class according to the Koppen classification.

## 3. Analysis for Temperature
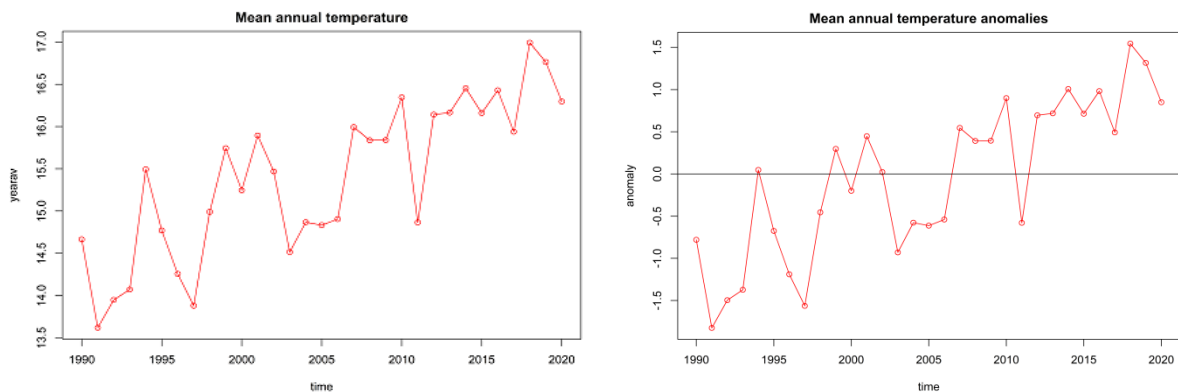## a) Mean Annual Temperature Analysis



Figure 3: Annual Mean Temperature & Anomalies

**(Figure 3)** In 1990, the annual average temperature was around 14.6 degrees Celsius, while in 2020; the annual average temperature reached 16.5 degrees Celsius. In this 30-year period, the annual average temperature value decreases in some years, but the annual average temperature is in an increasing trend during 1990-2020 periods.

According to the average annual temperature anomaly graph, while the deviations from the average were mostly negative until 2005, an increase in positive deviations was observed after 2005.

**b)   Temperature Extremes**
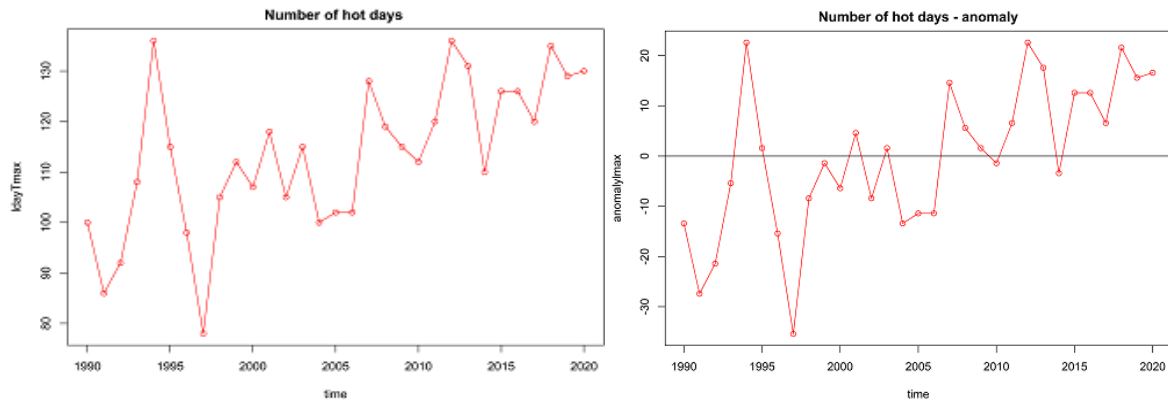


Figure 4: Number of Hot Day and Anomalies

**(Figure 4)** Since Istanbul has a Mediterranean climate, the maximum temperature value has been determined as 25 degrees. In the Number of hot days graph, the y-axis shows the number of days that exceed this threshold temperature value (25C). Over 130 hot days were observed both 1995 and 2013 years. This increase in the number of hot days in 1995 (Figure 5, left) caused the negative value deviation to approach its average value in the mean annual temperature anomalies graph (Figure 4, right) between 1990 and 1995. The decrease in the number of hot days observed between 1995 and 2000 (Figure 4, left), deviated the mean annual temperature anomalies graph from the average value negatively in 1995(Figure 3, right).

According to the Number of hot day - anomaly graph (Figure 4, right), while the deviations from the average in the number of hot days were generally negative until 2000 (except 1995), the deviations from the average remained mostly in positive values or in the average value after 2005.
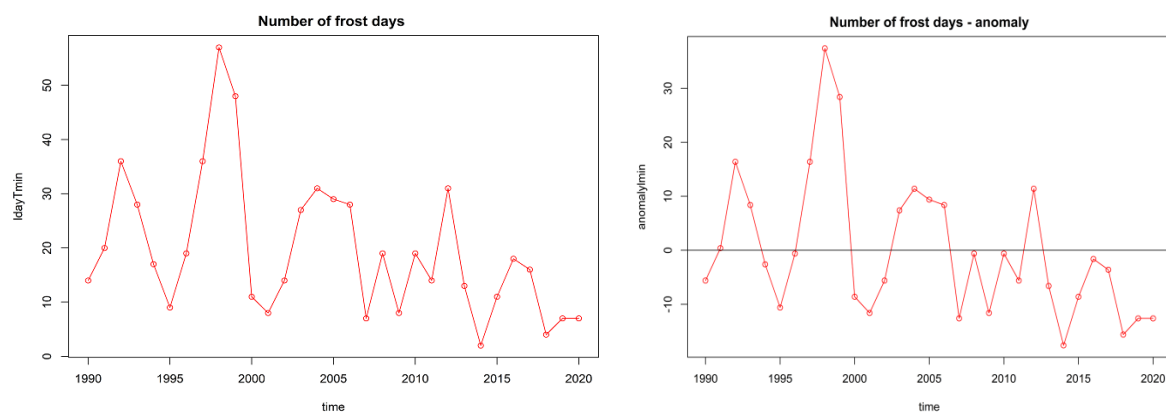


Figure 5: Number of Frost day and Anomalies

**(Figure 5)** Since Istanbul is located in the warm Mediterranean climate zone, the temperature rarely drops below zero. The threshold value was accepted as zero for number of cold days analysis. In Figure 5, on the left, the days when the temperature is below zero according to the years are analyzed. Figure 5 on the right shows the number of frost days anomaly.

It was mentioned that there was a decrease in the number of hot day graph between 1995 and 2000. In relation to this, there is an increase in the number of frost days in the same period. Similarly, while an increase was observed in the number of hot days in the period after 2005, there was a decrease in the number of frost days.
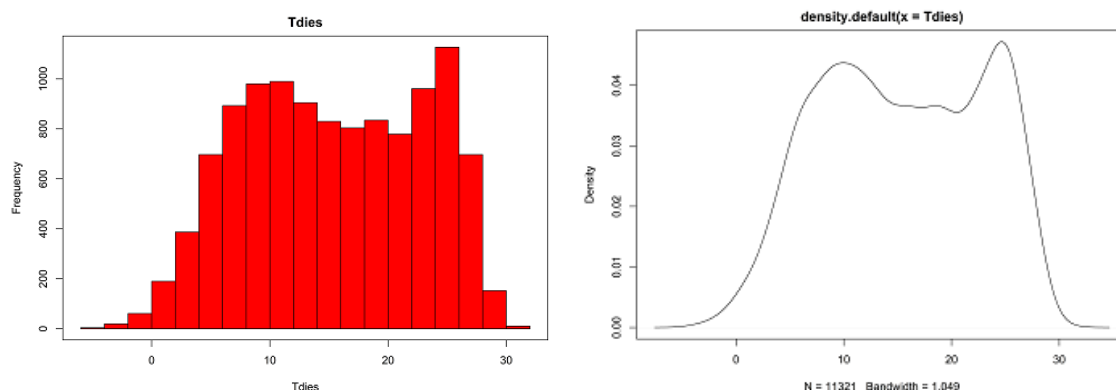
### c) Temperature histogram analysis



**Figure 6:  Histogram and Density function of the daily mean temperature (˚C)**

(**Figure 6**) shows a bimodal histogram and summarizes a dataset containing daily mean temperatures observed in the period 1990-2020. It shows that the probability of finding mean temperatures less than 0˚C is very low and most of mean temperatures lie between 6˚C and 28˚C. Also there is a probability of finding mean temperatures greater than 30˚C.In the figure shown above; there is a peak around 10˚C and a peak around 27˚C.

| Min. | 1st Qu. | Median | Mean | 3rd Qu. | Max. | |
|------|---------|--------|------|---------|------|---|
| -4.40 | 9.20 | 15.30 | 15.45 | 22.30 | 31.50 | |
| | | | | | | |
| Min. | 1st Qu. | Median | Mean | 3rd Qu. | Max. | NA's |
| 0.000 | 0.000 | 0.000 | 1.797 | 0.510 | 257.050 | 98 |

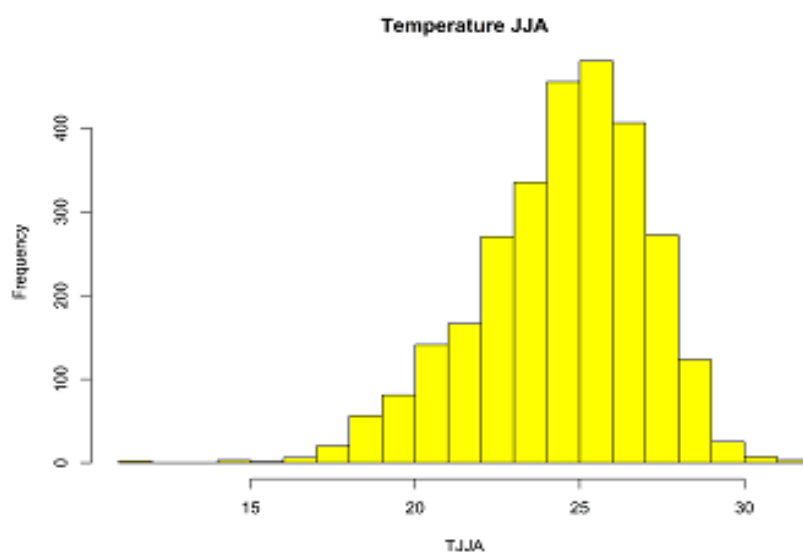### d) Histogram analysis according to seasons



**Figure 7: Histogram of the daily mean temperature for Jun July August (˚C).**

**(Figure 7)** Represents a negatively (left) skewed histogram and summarizes a dataset containing daily mean temperatures observed in the period 1990-2020 for Jun, July and August. It shows that the probability of finding maximum temperatures less than 19°C is very low and most of maximum temperatures lie between 24°C and 27°C. Also there is a probability of finding maximum temperatures greater than 30°C.
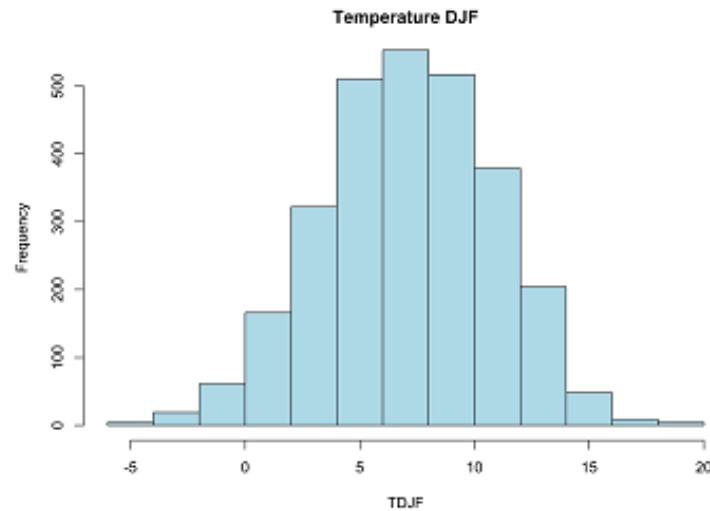


**Figure 8 Histogram of the daily temperature for December, January and February (°C).**

**(Figure 8)** Represents a Bell shaped / symmetric histogram, it summarizes a dataset containing daily mean temperatures observed in the period 1990-2020 (JJF) and the bimodality is due to the fact that the dataset is homogenou**s**. Also, it concludes that the probability of finding minimum temperatures less than -4°C is very low and most of daily mean temperatures lie between 2°C and 12°C. Also the probability of finding daily mean temperatures more than 16°C is also low.

## 4. Analysis for Precipitation

### a) Annual total precipitation
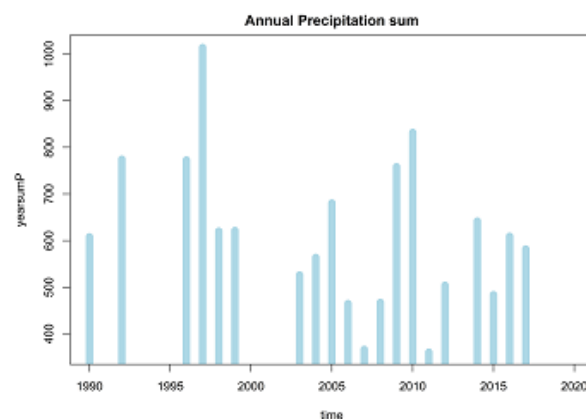


**Figure 9 Annual Precipitation um**

**(Figure 9)** In the annual total precipitation graph, the total precipitation amount from 1990 to 2020 was analyzed. If there is no precipitation data for any month during the year, it is not included in the total. Therefore, only years with precipitation data for each month were taken into account. According to the available data, the annual total precipitation amount could reach up to 1000 mm between 1995 and 2000, but this value was not observed after 2005.
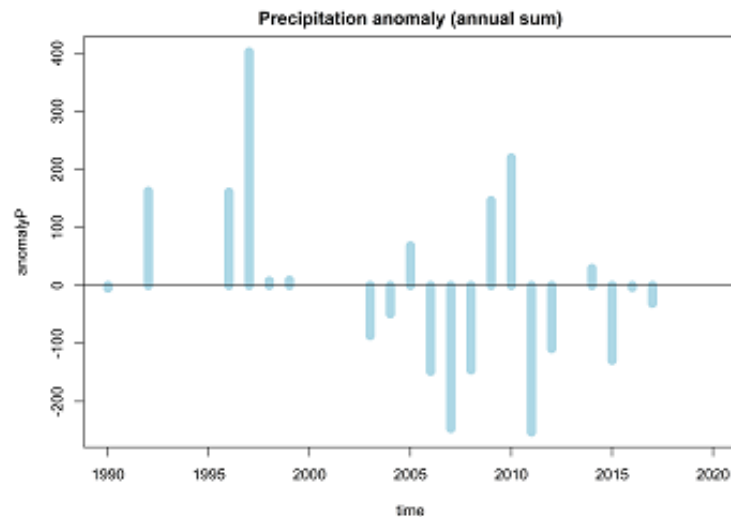
Figure 10 Precipitation anomaly (annual sum)

**(Figure 10)** In the annual total precipitation anomaly graph, while there was a positive deviation from the average before 2000, the deviation from the average was more negative after 2000. From 1990 to 2000, there is a decrease in the annual total precipitation.

### b) Number of days with precipitation analysis

It was mentioned above that in the annual total precipitation graph, when there is no precipitation in any month, the total precipitation of the whole year is considered zero. To observe the change in precipitation, the number of days with precipitation graph should be considered.
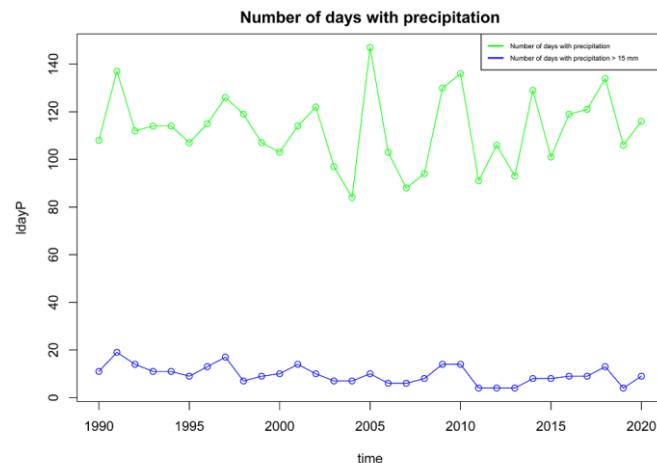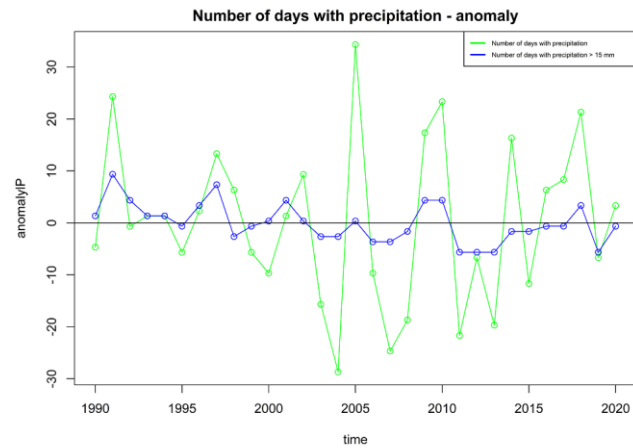


Figure 11 Number of days with precipitation

**(Figure 11)** In the graph, the total number of days with precipitation is given by years. The green line represents the number of day with precipitation with zero threshold value. The blue line is represents the number of day with precipitation with 15 mm threshold value. While number of days with precipitation is about 110 days in 1990, it reached 140 days after 1990 and decreased to nearly 110 days again in 1995. The year with the least number of days with precipitation was 2004 with less than 90 days. The year with the highest number of rainy days was 2005 with more than 140 days. The number of rainy days after 2005 varies between approximately 90 days and approximately 130 days.

The number of extreme rainy days does not exceed 20 days. The years with the most extreme precipitation are 1990 (20 days), 1995 to 2000 (approximately 20 days), 2001/2002, and 2010.

Figure 12 Number of days with precipitation anomalies

**(Figure 12)** The green line shows the anomaly of the number of rainy days, and the blue line shows the anomaly of the number of rainy days exceeding 15 mm. It is clear that both lines follow the same pattern.

Between 1990 and 1995, the number of day with precipitation and number of day with extreme precipitation is higher than the average.

From 1995 to 2000, both lines are at or above the average value. The number of precipitation days in 2004 (before 2005) is in such a negative trend that it reaches -30. The number of extreme precipitation days decreased less in the same period. The period between 2000 and 2005 can be considered as a dry period, considering both the fact that the number of precipitation days is below the average and the annual total precipitation is less than the average (Figure 9).

Number of extreme precipitation days increased in 2010 and decreased in the following period. Again, after 2010, there was a serious decrease in the number of rainy days and this period lasted until 2015. Between 2010 and 2015, it can be considered as a dry period due to both the fact that the number of rainy days is below the average and the annual total precipitation is below the average in the annual total precipitation anomaly (Figure 10). The number of rainy days in 2015 and 2020 remained at approximately the average level.

c)   **Histogram for total annual precipitation**
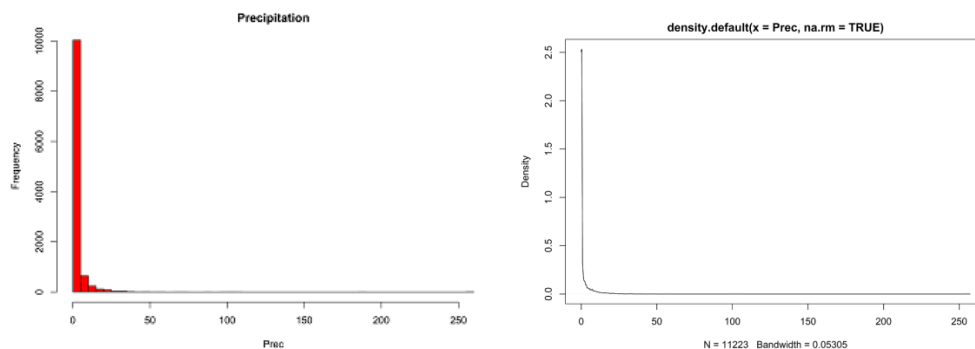


Figure 15 Histogram for total precipitation and density function

| Min. | 1st Qu. | Median | Mean | 3rd Qu. | Max. | NA's |
|------|---------|--------|------|---------|------|------|
| 0.000 | 0.000 | 0.000 | 1.797 | 0.510 | 257.050 | 98 |

The average precipitation between 1990 and 2020 is 1,797 mm. between these years; the most frequently observed precipitation amount can be evaluated as 1.7 mm. The lower amount of precipitation occurred more warmly. Similarly, as the amount of precipitation approached 50 mm, the probability of this precipitation approached zero. That is, the probability of observing 50 mm of daily precipitation is very low. In the selected region, mostly low daily precipitation has occurred and this is more likely to happen.

**d)    Precipitation histogram analysis according to seasons**
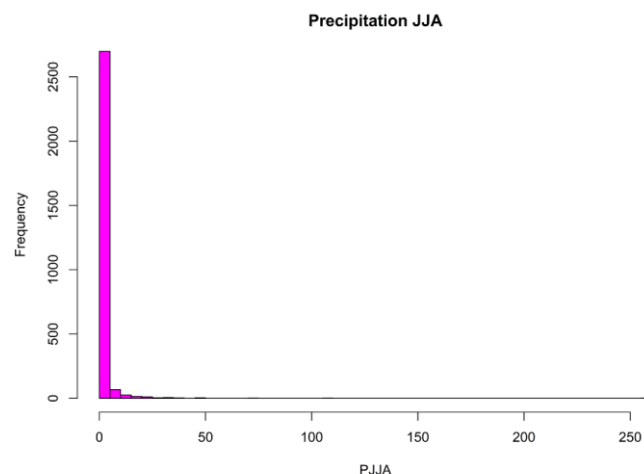


**Figure 16 Histogram of the daily precipitation for Jun, July and August (˚C).**

Low amount of precipitation in summer months was observed more frequently. Precipitation of 15 - 25 mm per day was also observed, but less than the low amount of precipitation. In addition, daily precipitation of 50 mm has been observed, albeit little, which is an indication that extreme events occur in Istanbul during the summer months.
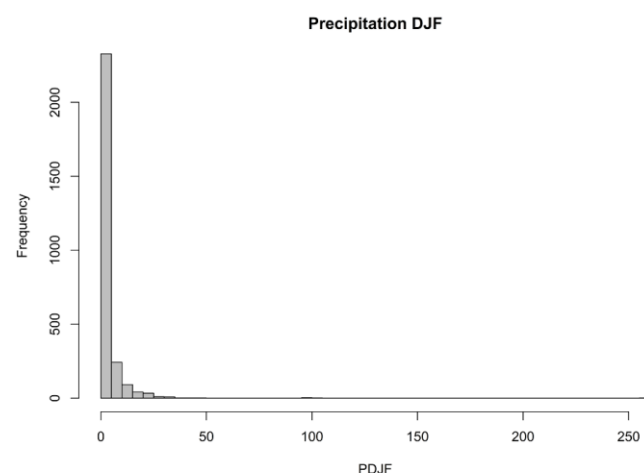


**Figure 17 Histogram of the daily precipitation for December, January and February (˚C).**

During the winter months, low daily precipitation occurs mostly. Precipitation reaching 15-25 mm also occurs, but the frequency is less.

**5.    Analysis with Observation and Reanalysis data from Climate KNMI Explore**
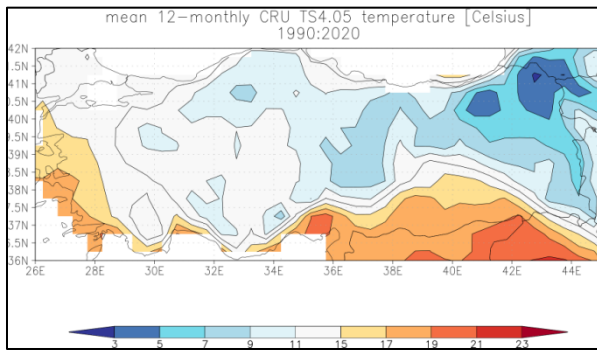
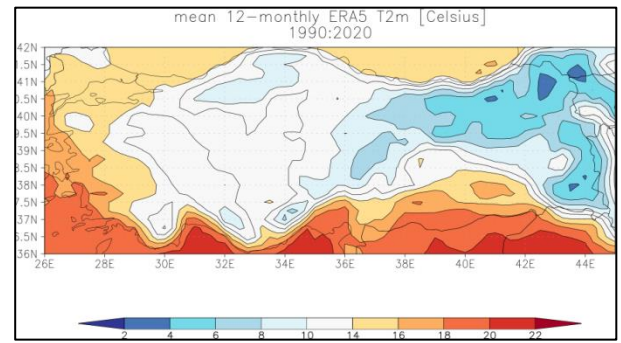Figure 18: Mean temperature map from observation data



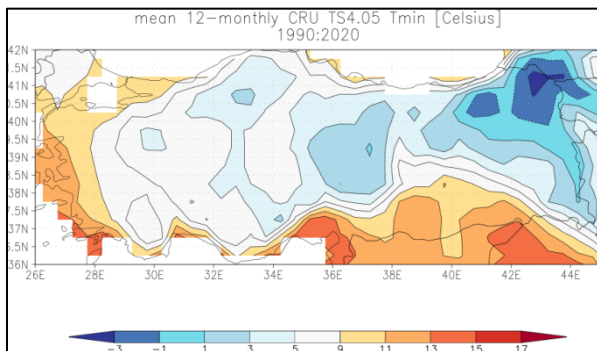Figure 19: Mean temperature map from reanalysis data



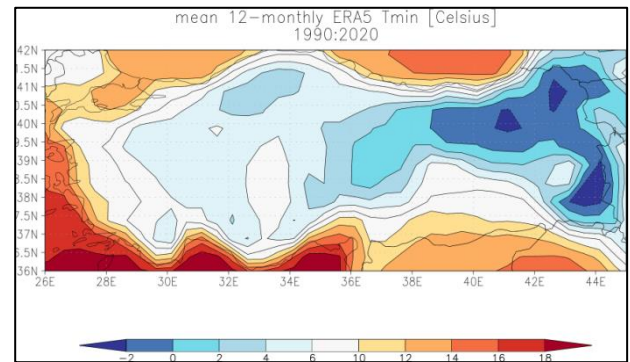Figure 20: min temperature chart from observation data



Figure 21: min temperature chart from reanalysis data
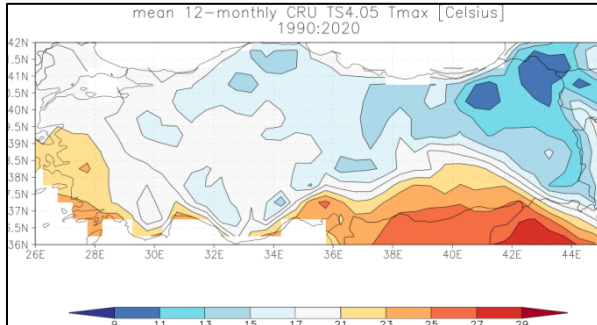


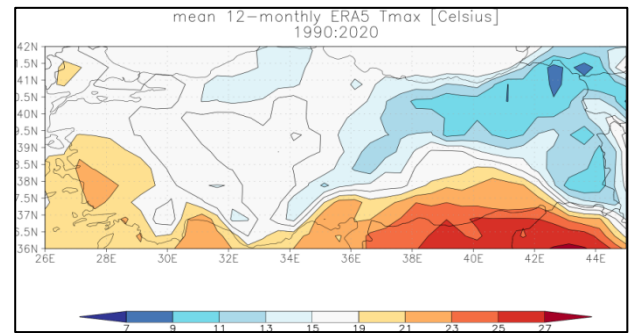Figure 22: max temperature chart from observation data



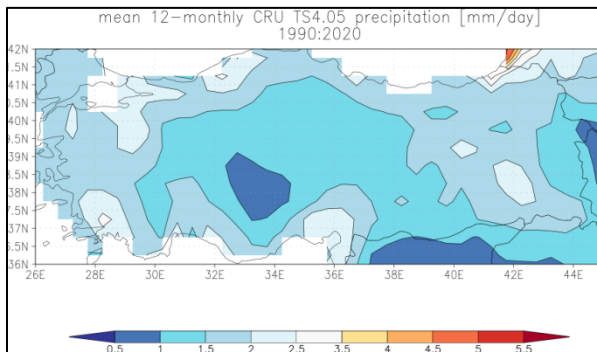Figure 23: max temperature chart from reanalysis data



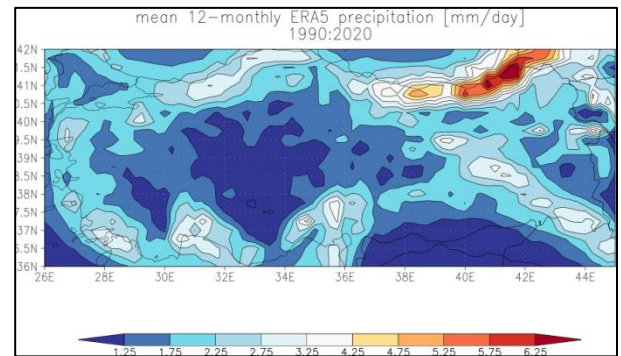Figure 24:  mean precipitation chart from observation data



Figure 25: mean precipitation chart from reanalysis data

## 6. Results and Discussion

**R program results**

According to the climatograph chart obtained for Istanbul, the temperature varies between +6 and +10 degrees in winter. In summer, the temperature ranges between 22 degrees and 26 degrees. In addition, while an increase in temperature is observed towards summer in the spring season, the temperature gradually decreases towards the winter in the autumn season.
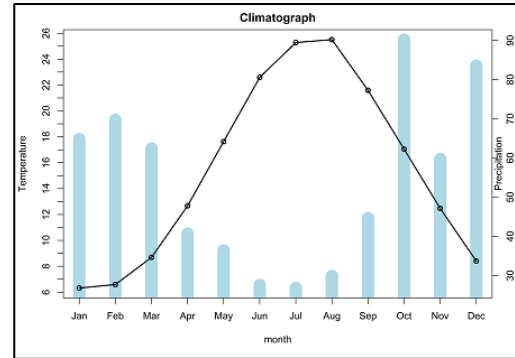


In winter, precipitation varies between 70 mm and 80 mm however, the rainiest period of the year is October. The driest period is June, July and August, when the temperature is the highest and the precipitation is the lowest. Spring and autumn periods are rainy and temperate.

When the number of hot day anomaly graph in figure 4 is evaluated, it is clear that the temperatures have been in an increasing trend since 2005.

According to the number of precipitation days and the number of extreme precipitation days (Figure 12), the number of rainy days has decreased after 2005, and therefore, drought is gradually increasing.

**Climate KNMI Explore Result**

In addition to graphics, maps are one of the important tools that describe the distribution of temperature and precipitation according to time and area. Mean temperature, maximum temperature; minimum temperature and precipitation analysis were performed using both CRUT4 observation data and ERA5 reanalysis data via Climate KNMI explorer.

While the monthly average temperature of Istanbul is between 11-15 degrees according to the observation data, it is between 14-15 degrees according to the reanalysis data.

While the monthly average minimum temperature data is between 5-9 degrees according to the observation data, it is between 12-14 degrees according to the map obtained from the ERA5 data.

According to the monthly average maximum temperature map observation data, it is between 17 and 21, and according to the ERA5 data, it is between 15 and 19 degree.

According to the CRU observation data, the daily average precipitation is 2-2.5 mm, while according to the ERA5 data, the average daily precipitation is between 1.75 and 2.25 mm.