

Climate of Turkey

Serhat Sensoy 1, ssensoy@mgm.gov.tr, Mesut Demircan 1, Yusuf Ulupinar 1
1. Turkish State Meteorological Service, P.O.Box: 401, Ankara, Turkey

Although Turkey is situated in large Mediterranean geographical location where climatic conditions are quite temperate, diverse nature of the landscape, and the existence in particular of the mountains that run parallel to the coasts, result in significant differences in climatic conditions from one region to the other. While the coastal areas enjoy milder climates, the inland Anatolian plateau experiences extremes of hot summers and cold winters with limited rainfall (Sensoy et al, 2008).

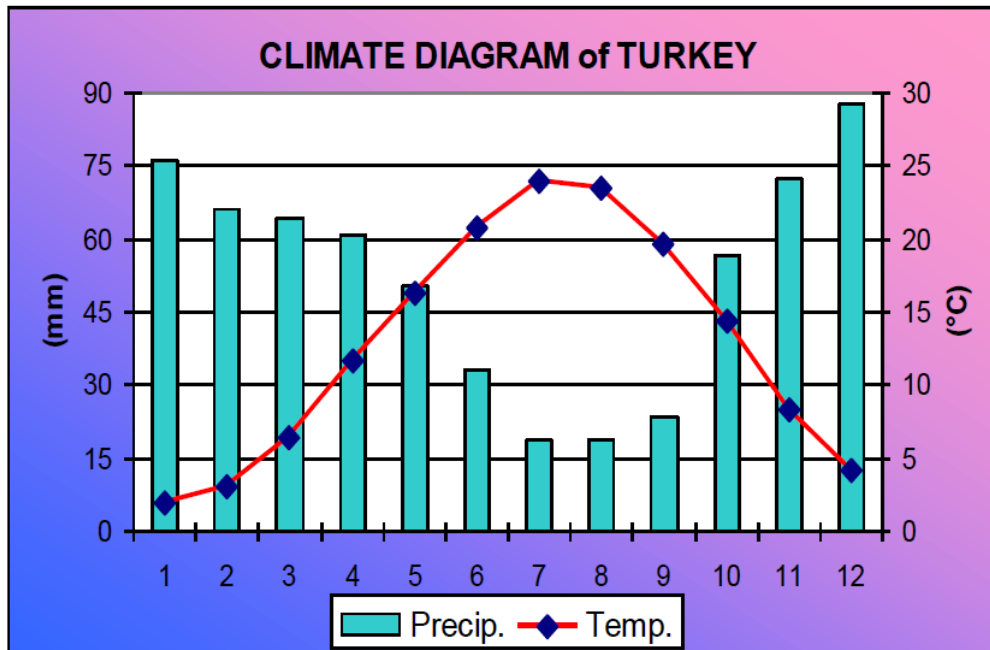


Figure 1. Climate diagram of Turkey

Turkey receives most of the rainfall in the winter season. In this season, mean temperature usually is below 5°C and there is no too much evaporation. But summer rainfall is very limited and could not be enough to remove water deficit resulted from increased temperature and evaporation.

The Aegean and Mediterranean coasts have cool, rainy winters and hot, moderately dry summers. Annual precipitation in those areas varies from 580 to 1,300 millimeters, depending on location. The Black Sea coast receives the greatest amount of rainfall. The eastern part of that receives 2,200 millimeters annually and is the only region of Turkey that receives rainfall throughout the year.

Turkey's diverse regions have different climates because of irregular topography. Taurus Mountains are close to the coast and rain clouds cannot penetrate to the interior part of the country. Rain clouds drop most of their water on the coastal area. As rain clouds pass over the mountains and reach central Anatolia they have no significant capability to produce of rain. In the Eastern region of Anatolia, the elevation of mountains exceeds 2500-3000 m. Northern Black Sea Mountains and Caucasian Mountain hold the rain clouds, and therefore the area is affected by the continental climate with long and very cold winter. Minimum temperatures of -30°C to -38°C are observed in the mountainous areas in the east, and snow may lie on the ground 120 days of the year. Winters are bitterly cold with frequent, heavy snowfall. Villages in thee region remain isolated for several days during winter storms.

1. Temperature

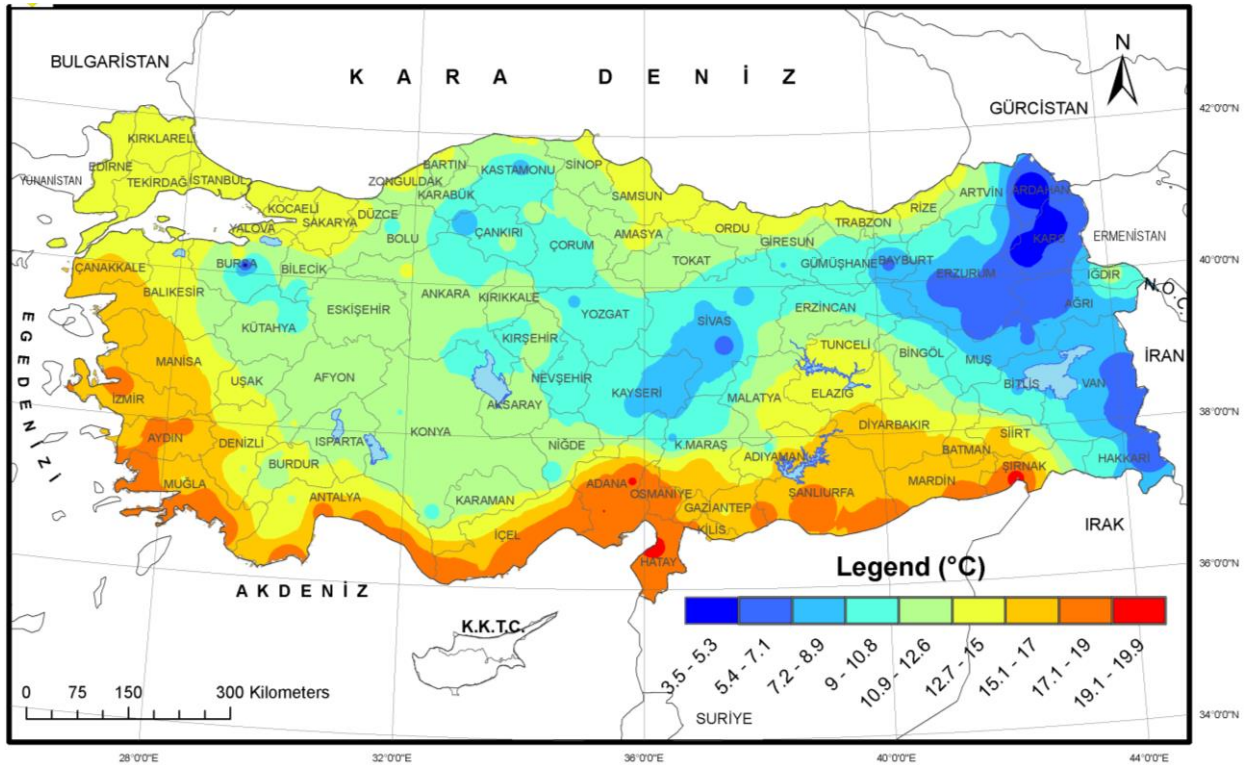


Figure 2. Geographical distribution of mean annual temperature URL 1)

In Istanbul and around the Sea of Marmara the climate is moderate (winter 4°C and summer 27°C); in winter however the temperatures can drop below zero. In Western Anatolia, there is a mild Mediterranean climate with average temperatures of 9°C in winter and 29°C in summer. On the southern coast of Anatolia the similar climatic condition are observed. The climate of the Anatolian Plateau is a steppe climate. There is a great temperature difference between day and night. Rainfall is low but it usually in form of snow. The average temperature is 23°C in summer and -2°C in winter. The climate in the Black Sea area is wet, and humid (summer 23°C, winter 7°C). In the Eastern Anatolia region there is a long winter, and snow remains on the ground from November until the end of April (the average temperature in winter is -13 °C and in summer 17 °C). In the South-Eastern Anatolia region, summers are hot and dry, with temperatures above 30°C. Spring and autumn are generally mild, but during both seasons sudden hot and cold spells frequently occur in the region.

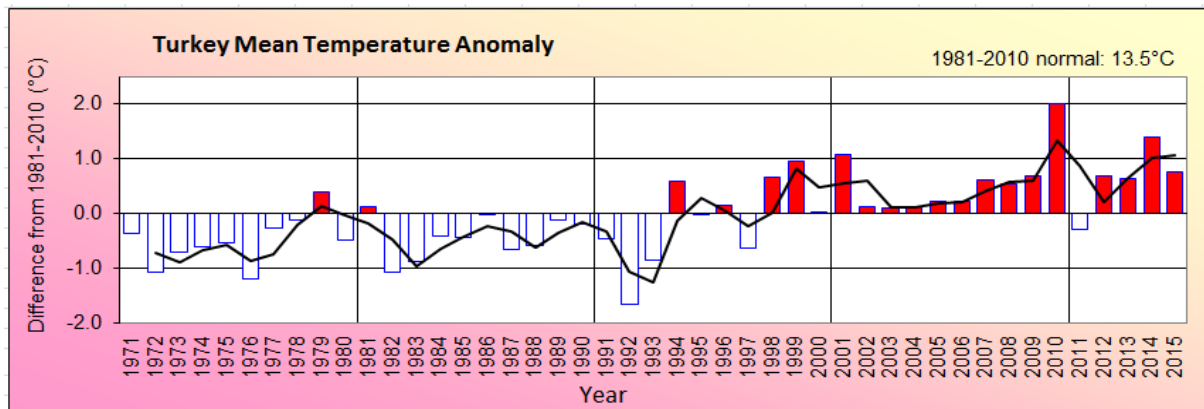


Figure 3. Turkey annual mean temperature anomalies (Sensoy et al, 2016).

Turkey mean temperature for the 1981-2010 climatic periods is about 13.5°C and there have been positive temperature anomalies since 1998 except 2011. The year 2010 was the warmest year.

1.1. Heat and cold waves

Heat wave is daily maximum temperature on more than five consecutive days exceeding the average maximum temperature by 5°C (Frich et al., 2002). Cold wave is daily minimum temperature on more than five consecutive days below the average min. temperature by 5°C.

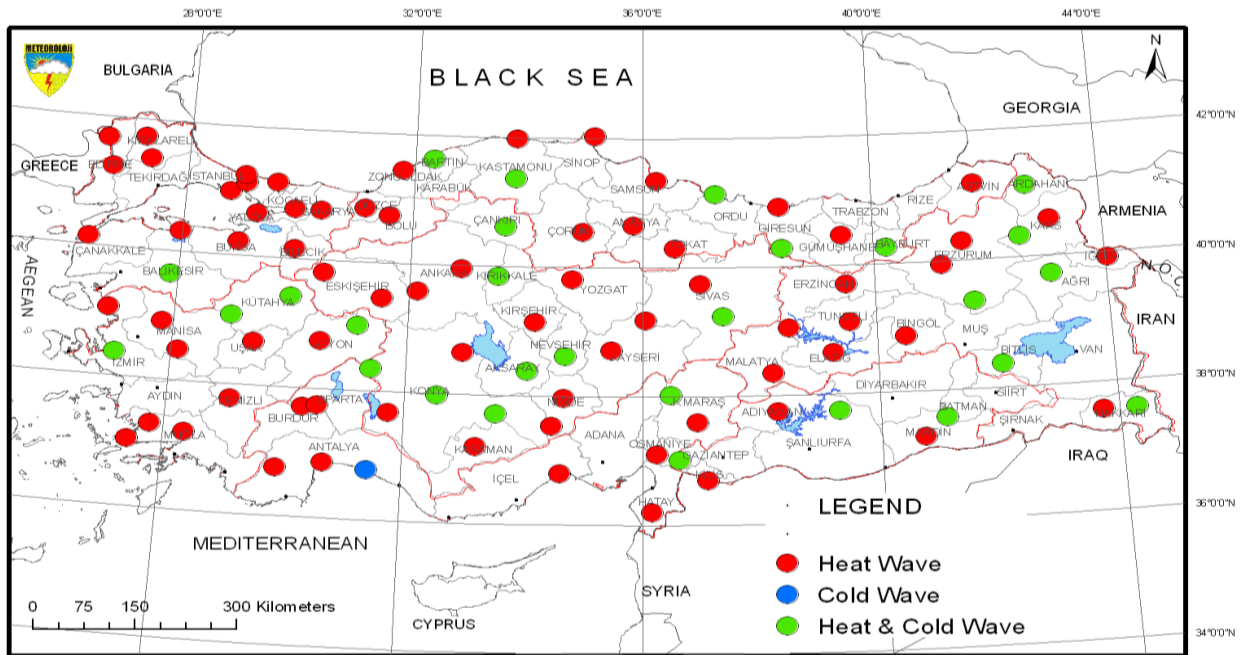


Figure 4. Occurred heat and cold wave's spatial distribution in 2015 (Sensoy et al, 2016).

Nowadays heatwaves are occurring frequently in the country. For example in 2015 72 stations had heatwaves (some of them more than once), 28 stations had both heat and cold waves.

1.2. Extreme temperatures

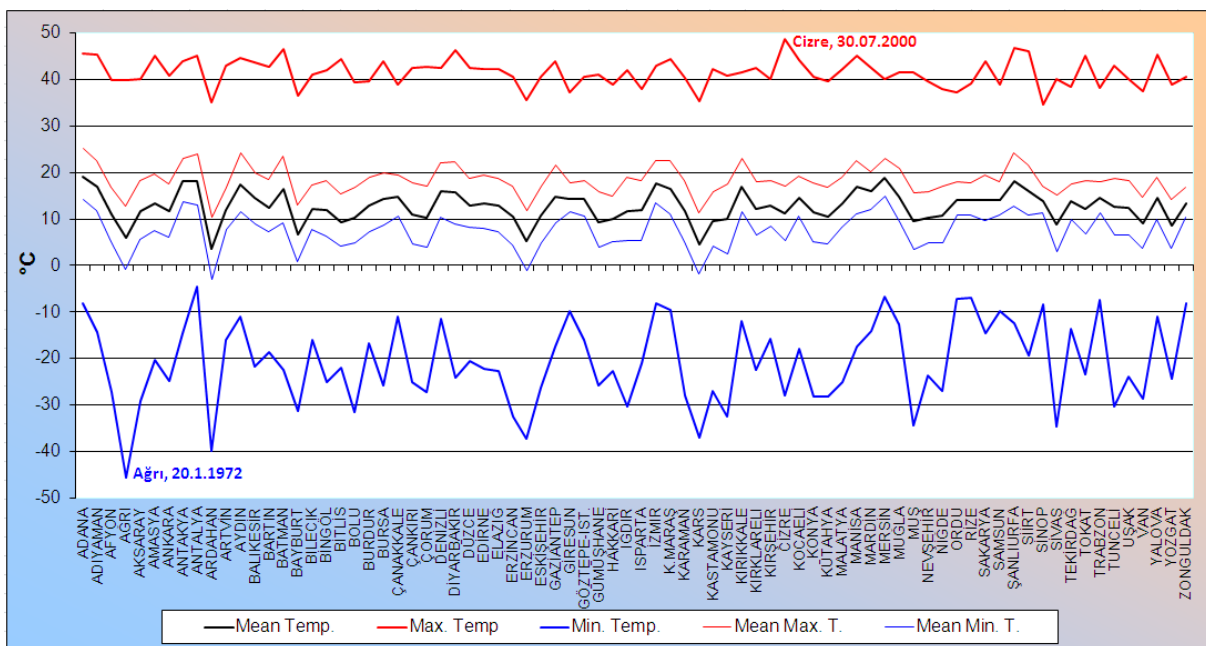


Figure 5. Long term temperatures of the Cities

Lowest temperature in Turkey was on 20th January, 1972 with -45.6°C in Ağrı while highest temperature was in 30th July, 2000 with 48.6°C in Cizre, Şırnak. Minimum temperature has warming trends the last decades and not broken the Ağrı's record again.

2. Areal Precipitation



Figure 6. Geographical distribution of areal annual precipitation (1981-2010) (URL 2)

A big difference is observed when the total rainfall between coastal and inland stations, are compared. The Black Sea coasts (Rize, Hopa) receive greatest amount of rainfall while Konya and Iğdır less. Annual precipitation amount of Turkey is mainly determined by elevation. The Aegean and Mediterranean coasts have rainy conditions in winters but dry in summers. The Black Sea coast receives the greatest amount of rainfall and is the only region of Turkey that receives rainfall throughout the year.

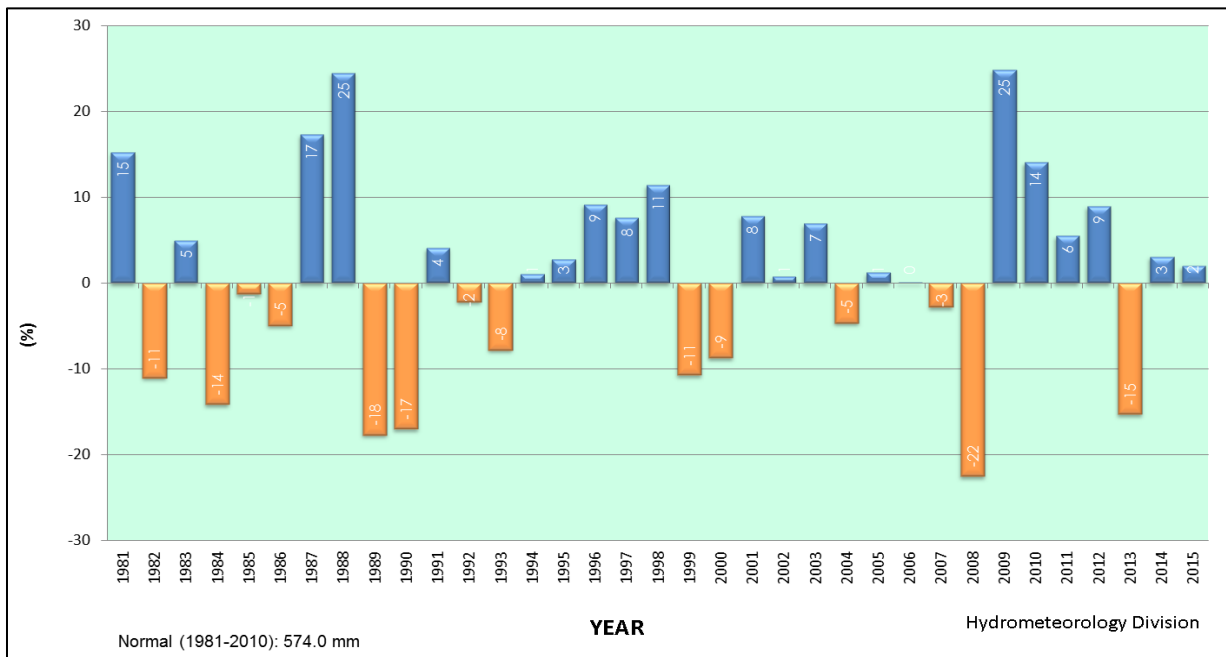


Figure 7. Turkey annual precipitation anomalies

Annual average areal precipitation of Turkey for the 1981-2010 climatic period is about 574 mm. Dry and wet periods are chasing each other in Turkey.

2.1. Regional differences in the rainfall

Large mountains influence regional climates. For example Turkey's diverse regions have different climates because of irregular topography. Taurus Mountains are close to the coast and rain clouds cannot penetrate to the interior part of the country. Rain clouds drop most of their water on the coastal area. As rain clouds pass over the mountains and reach central Anatolia they have no significant capability to produce of rain.

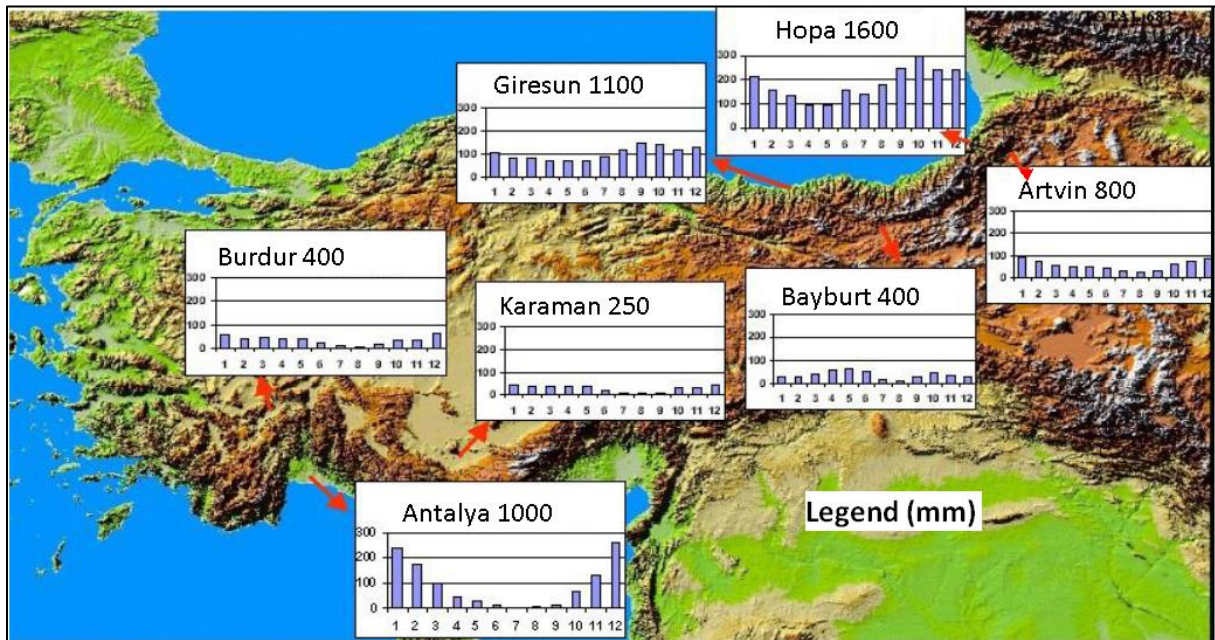


Figure 8. The Mountain influence on Turkey precipitation (Sensoy, 2004' den modifiye).

A big difference is observed when the total rainfall between coastal stations and inland stations, are compared.

2.2. Seasonal differences in the rainfall

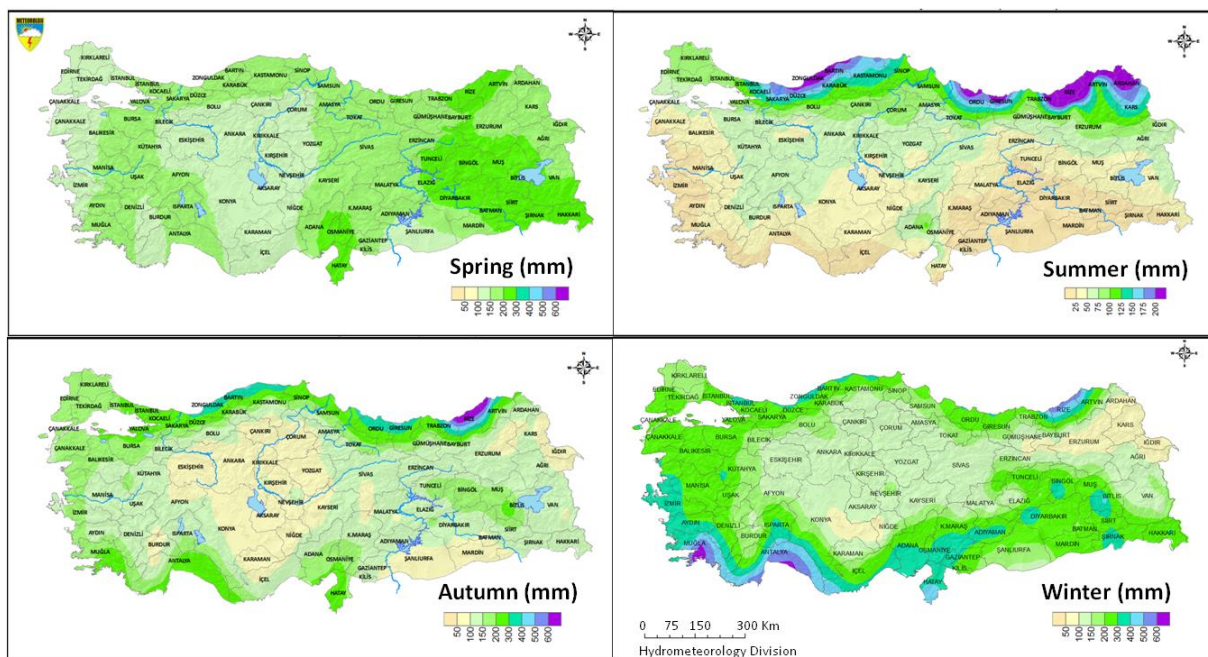


Figure 9. Seasonal areal rainfall distribution in Turkey (Sensoy et al, 2016).

A big difference is observed also between seasonal rainfalls. The Aegean and Mediterranean coasts have rainy in winters but dry in summers. Black sea coast has rainy in all season.

2.3. Extreme Rainfall

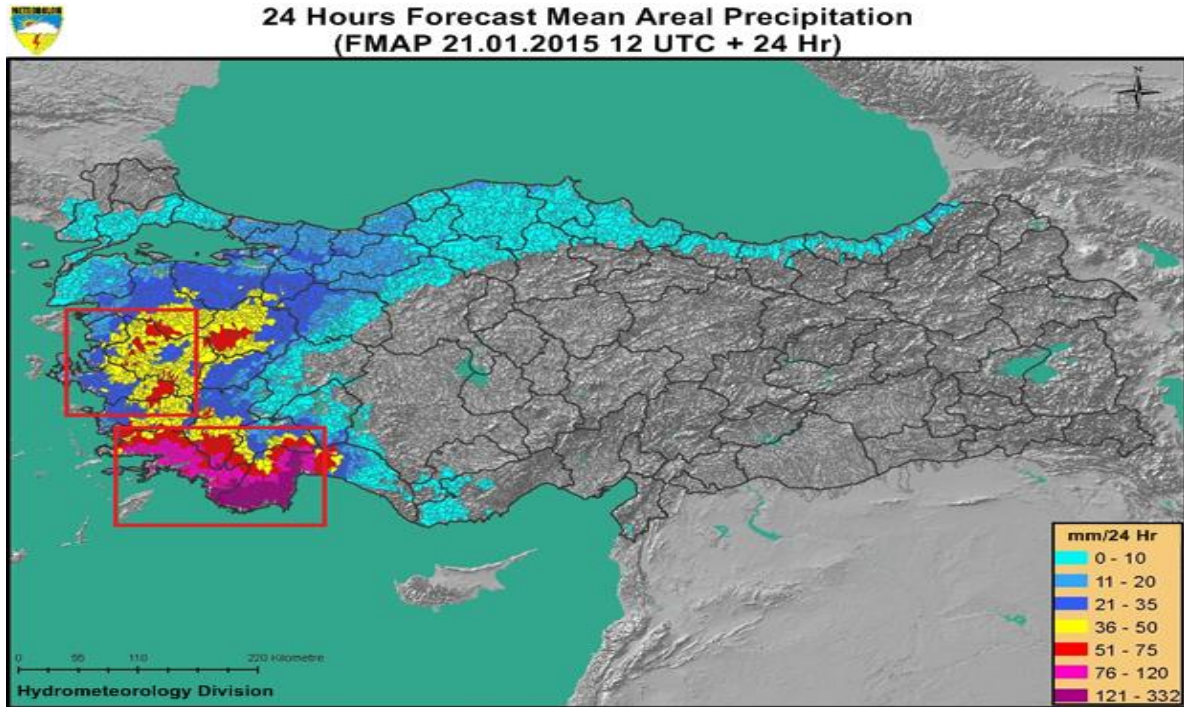


Figure 10. Hours Forecast Mean Areal Precipitation (21.01.2015 12:00 UTC + 24 Hr)

According to Black Sea Middle East Flash Flood Guidance System (FFGS) products which is used in TSMS, it is estimated that intensity precipitation for province of Antalya/Kas at 21 January 12:00 UTC. On the next day, 232.5 mm rainfall is observed in 24 hours which is over 100 year return period. Consequently, inundation events occurred in the town, highway was covered by mud and gravel pieces due to flood.

Table 1. Extreme rainfall amounts in Turkey in specific time interval

Duration	Amount (mm)	Station	Date
5 minute	50.5	Hopa	07.Tem.88
10 minute	60.6	Hopa	07.Tem.88
15 minute	70.7	Hopa	07.Tem.88
30 minute	90.9	Hopa	07.Tem.88
1 hour	131.0	Antalya	03.Kas.95
2 hour	180.5	Antalya	03.Kas.95
3 hour	230.9	Marmaris	11.Ara.92
4 hour	332.3	Antalya	04.Kas.95
5 hour	374.3	Antalya	04.Kas.95
6 hour	390.3	Antalya	04.Kas.95
8 hour	410.4	Antalya	04.Kas.95
12 hour	428.1	Antalya	04.Kas.95
18 hour	464.8	Marmaris	10-11 Ara.92
24 hour	466.3	Marmaris	10-11 Ara.92

According to extreme rainfall analysis of Turkey, we can see minute extremes in Hopa while hourly extremes occurred in Marmaris and Antalya (Table 1).

3. Climate classification of Turkey via Thornthwaite method

Thornthwaite climate classification depends on precipitation - evaporation and temperature - evaporation relations. According to Thornthwaite, if precipitation more than evaporation there soil is wet. On the other hand, if precipitation is less than evaporation there is water deficit there. Soil couldn't be given enough water to plant. So this area is dry.

Rainfall effectiveness indice

Table 2. Thornthwaite index and climate types

Im	Letter	Climate types
>100	A	Very humid
100-80	B4	Humid
80-60	B3	Humid
60-40	B2	Humid
40-20	B1	Humid
20-0	C2	Semi humid
0-(-20)	C1	S. dry-less humid
-20-(-40)	D	Semi dry
-40-(-60)	E	Dry

$$I_m = \frac{100 S - 60 d}{ETP} \quad \text{Where;}$$

S = annual water surplus,

d = annual water deficit

ETP = annual evapotranspiration

Calculation for Şanlıurfa:

$$I_m = \frac{(100 \times 193) - (60 \times 761.8)}{1030} = -26$$

Şanlıurfa 1st letter is **D** (semi dry)

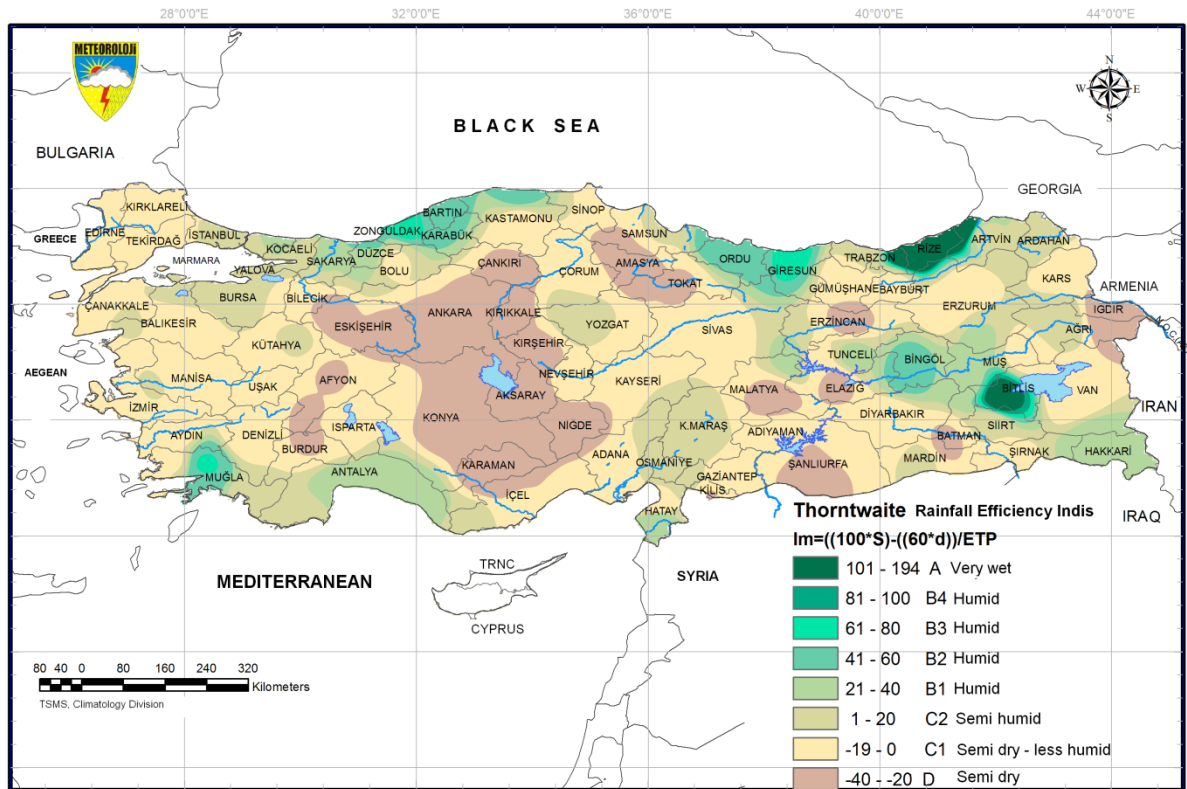


Figure 11. Climate classification of Turkey via Thornthwaite method (Sensoy et al, 2012)

According to Thornthwaite method; semi dry areas are the inland Anatolia, Iğdır and Şanlıurfa; very wet region is the Eastern Black Sea; humid regions are Black sea and the around of Bitlis and Muğla and the other large areas of Turkey are semi dry and semi humid climatic regions (Sensoy et al, 2012).

4. Renewable energy sources

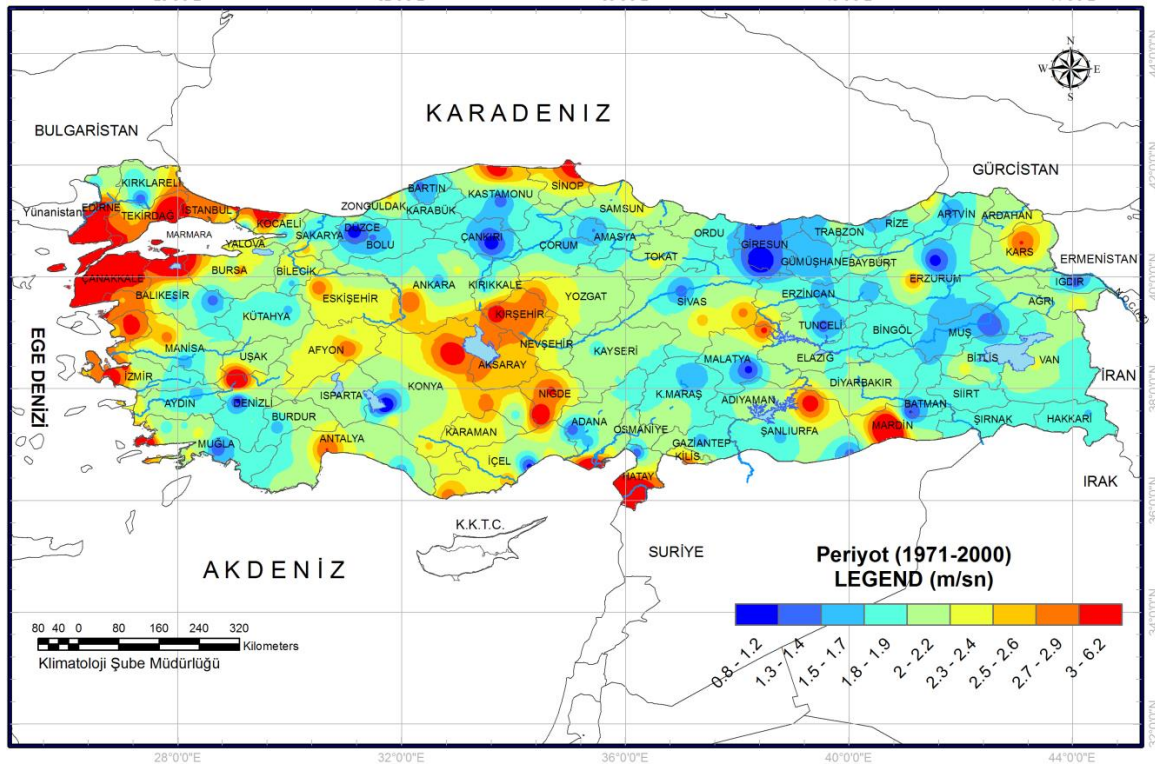


Figure 12. Average wind speed distribution over Turkey (Sensoy et al, 2008)

Average wind speed distribution over Turkey shows that, there is a great wind energy potential in Çanakkale, İstanbul, Sinop, Aksaray, Kırşehir, Hatay and Mardin.

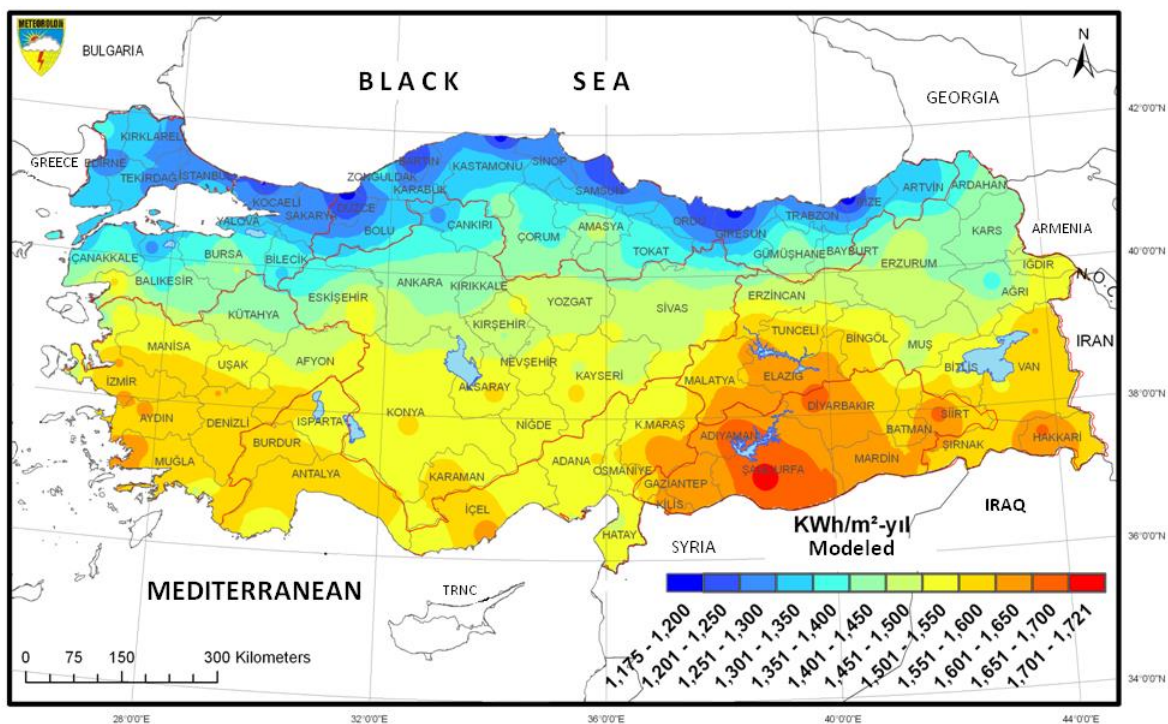


Figure 13. Modeled average total radiation distribution over Turkey

Modeled average total radiation distribution over Turkey shows that there is a great solar energy potential in the southern parts of the country (Sensoy et al, 2010).

5. Extreme events

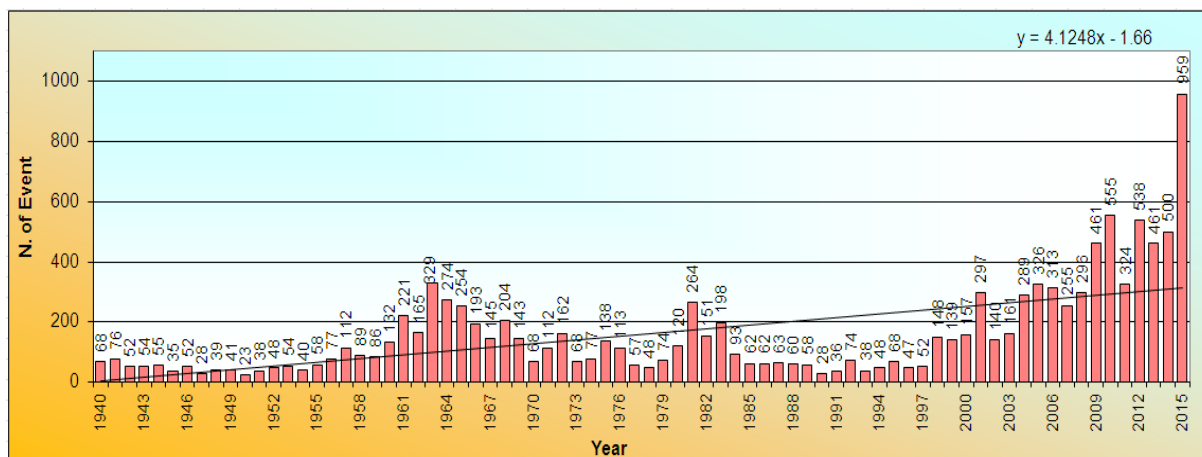


Figure 14. Annual count of extreme events in Turkey (Sensoy et al, 2016).

The number of extreme events in 2015 reached 959 (Fig. 4.1) (URL 3 and URL7). There is an increasing trend in extreme event (41events/decade).

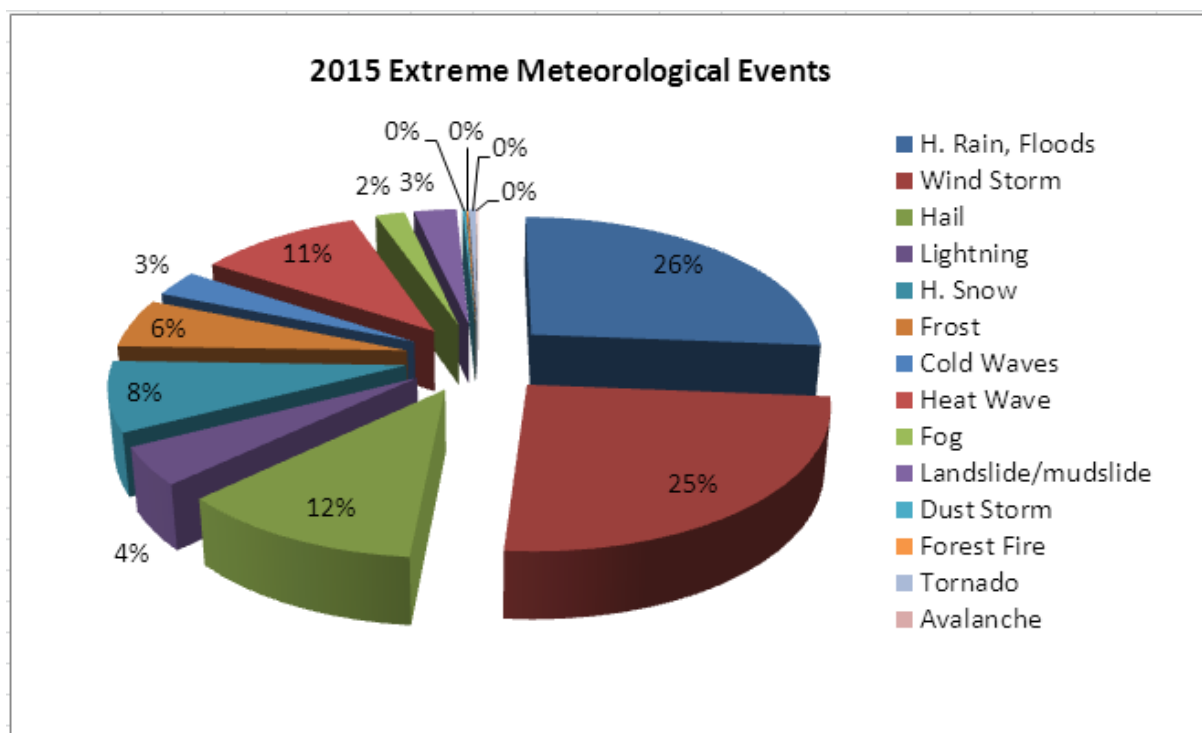


Figure 15. Distribution of extreme events types in Turkey in 2015, (URL 3 and URL7)

During 2015 most hazardous extreme events were heavy rain/floods (26%), wind storm (25%), hail (12%), heat wave (11%), heavy snow (8%), frost (6%), lightning (4%), cold wave (3%), landslide/mudslide (3%) and fog (2%) respectively (Fig. 4.2). Although rare, 1 forest fire, 2 dust storm, 1 avalanche and 4 tornados also occurred in 2015 (URL 3 and URL7).

Several people died from chimney poisoning due south-westerly wind (Lodos) (Url 8). 9 people died from lightning. Also 1 people from landslide, 1 people from flood and 1 people from snow-load, were lost their life.

5.1. Hail



Figure 16. Hail storm on 20 May 2015 in İzmir (Url 3).

Hail storm caused floods and disruption in traffic in İzmir.

5.2. Frost and Floods



Figure 17. Frost damage in Finike (left), Floods in Greenhouse, Demre, Antalya (right) (Url 6).

Frost caused big damages on orange trees in Finike, Antalya, 100 km/h storm broken power lines and greenhouses were flooded in Demre on 13 January 2015.

6. Sand and Dust Storm

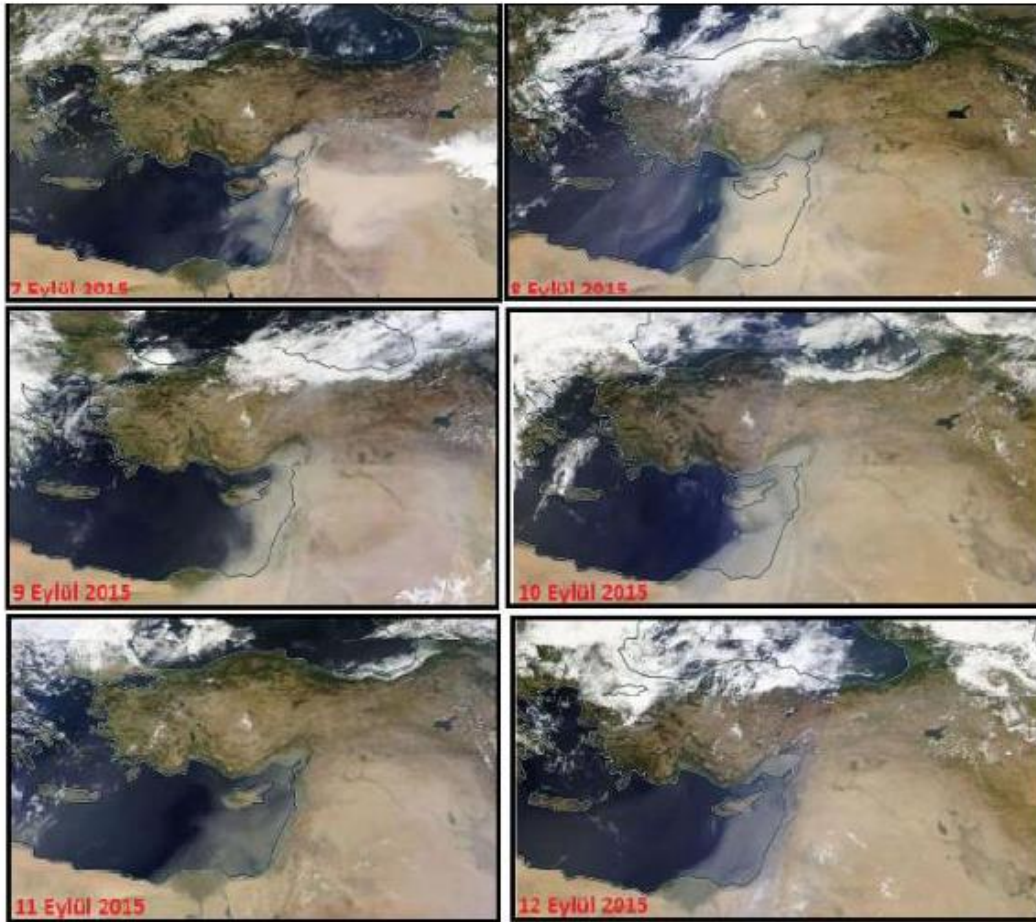


Figure 18. MODIS real time images for 07-12 September 2015 (URL 4).

Dust storm became a problem in Turkey in recent years. On 7-12 September, 2015 South Eastern Anatolia experienced dust transport coming from the Egypt and Syria. This was the longest time (5 days) dust storm in Turkey.

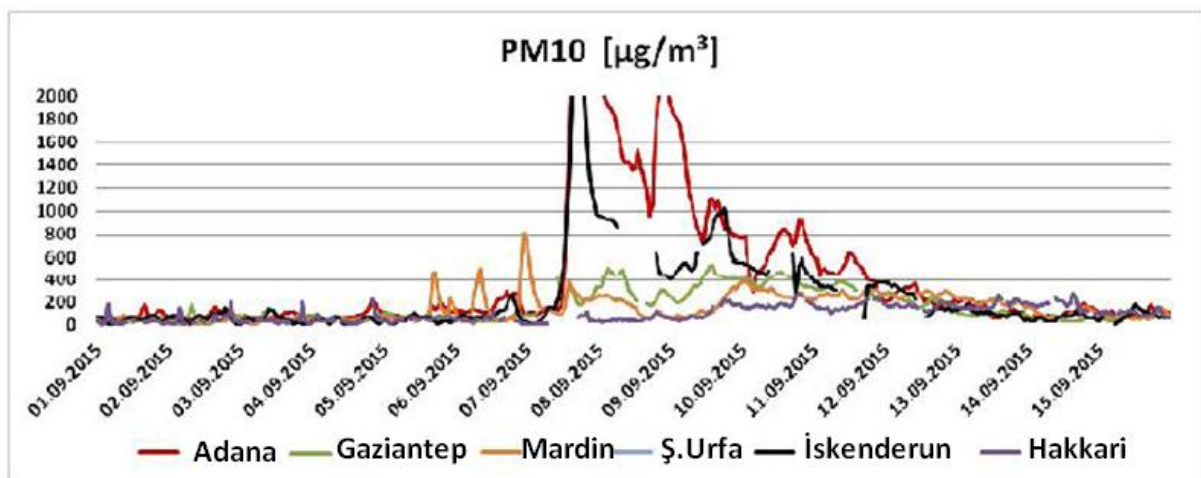


Figure 19. Particulate Matter (PM10) observation for 6 centers

Especially in Hatay and Adana particulate matter concentration has reached 2558 and 2774 $\mu\text{g}/\text{m}^3$ respectively (Oğuz et al, 2015).

7. Ozone measurements and analysis for Ankara, Turkey

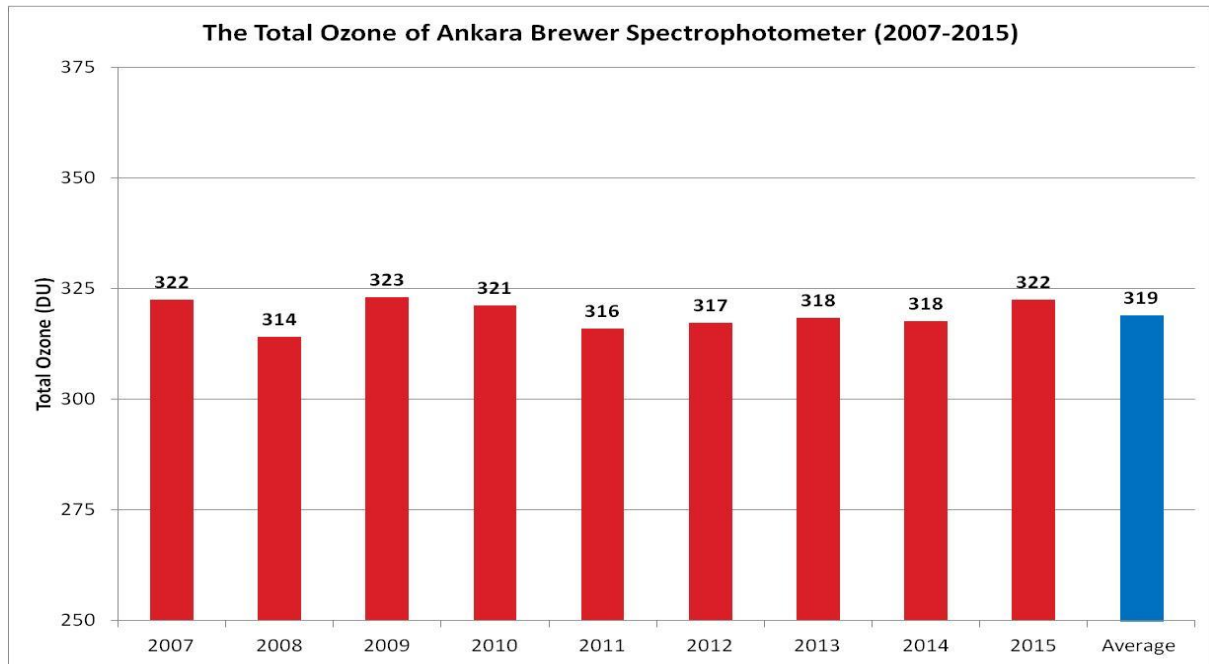


Figure 20. Total Ozone of Ankara Brewer Spectrophotometer (2007-2015)

Total column ozone has 319 DU average for the period of 2007-2015 over Ankara. The minimum total ozone value is seen in 2008 as 314 DU and the maximum value of total ozone amount is 323 DU in 2009.

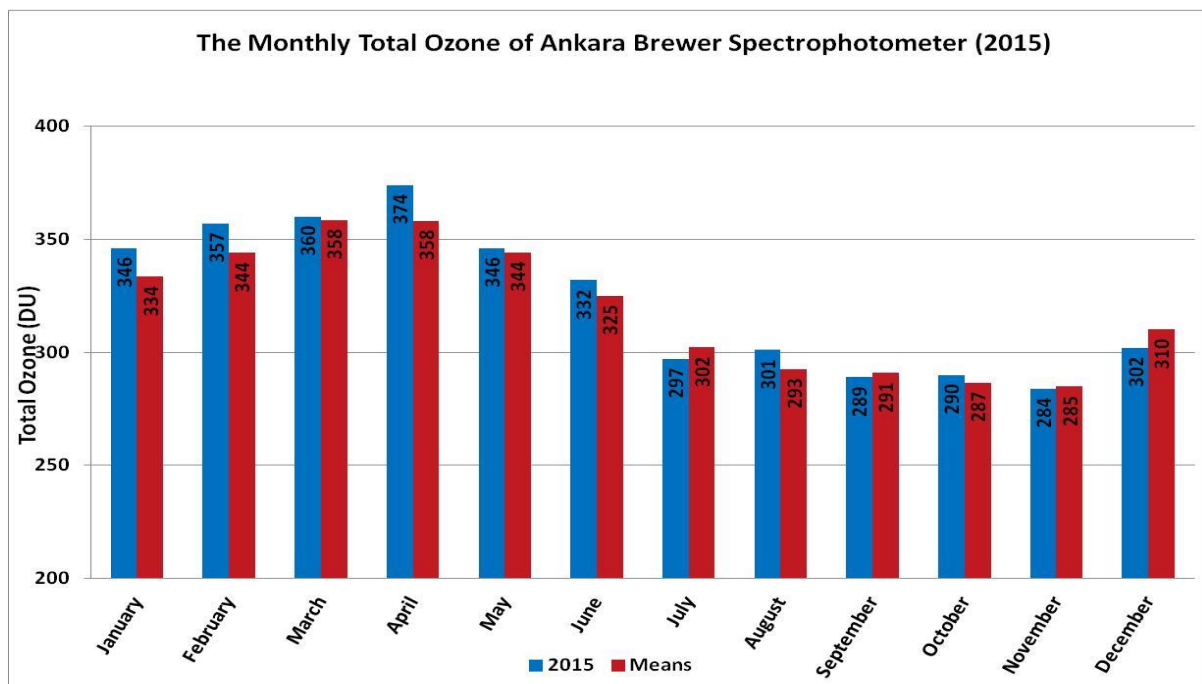


Figure 21. The monthly Total Ozone of Ankara Brewer Spectrophotometer in 2015

The monthly Brewer total ozone values of Ankara in 2015 were similar to the general trend in northern mid-latitudes. They were highest March and April: 360 and 374 DU, and lowest in September and November, 289 and 284 DU (Url 5).

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