

# Meteorological Drought in Turkey: A Historical Perspective, 1930–93

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The climate of Turkey, which is mainly characterized by the Mediterranean macro climate, results from the seasonal alternation of frontal depressions with polar air masses and subtropical high pressures with subsiding maritime tropical and continental tropical air masses. Continental tropical airstreams from the northern African and Arabian deserts particularly dominate throughout the summer, by causing long-lasting warm (hot) and dry conditions over Turkey (except the Black Sea region and northeastern Anatolia). Turkey has an area of 779,452 km<sup>2</sup> and an average elevation of 1,132 m.

This study outlines some spatial and temporal characteristics of Turkey's rainfall, particularly in terms of drought and rainfall variability for the period 1930–93. Mean characteristics of the rainfall data were investigated for 99 stations, and then variations of Turkey's 91-station normalized rainfall series and spatial distribution of the normalized rainfall index were analyzed. Average record length of these stations is about 60 years. Approximately 67% of the countrywide annual rainfall occurs during the cold winter (40%) and cool spring (26.6%), when the eastern Mediterranean basin, Balkans, and Turkey are influenced by the frontal mid-latitude and Mediterranean depressions. Contributions of autumn and summer rainfall are about 23% and 10%, respectively, of the annual total. In area-averaged series for the Mediterranean region, winter rainfall reaches its maximum value at about 53% of the annual total, and summer rainfall declines to about 4% of the annual total. The number of stations in each rainfall regime region is given in Table 1, and the location of 99 stations is shown in Figure 1.

Rainfall region	Number of stations
Black Sea (BLS)	9
Marmara–Mediterranean to Black Sea–Transition (MRT)	11
Mediterranean (MED)	24
Continental Mediterranean (CMED)	18
Mediterranean to Central Anatolia Transition (MEDT)	4
Continental Central Anatolia (CCAN)	22
Continental Eastern Anatolia (CEAN)	11

Table 1. Rainfall regions and number of stations in each region.

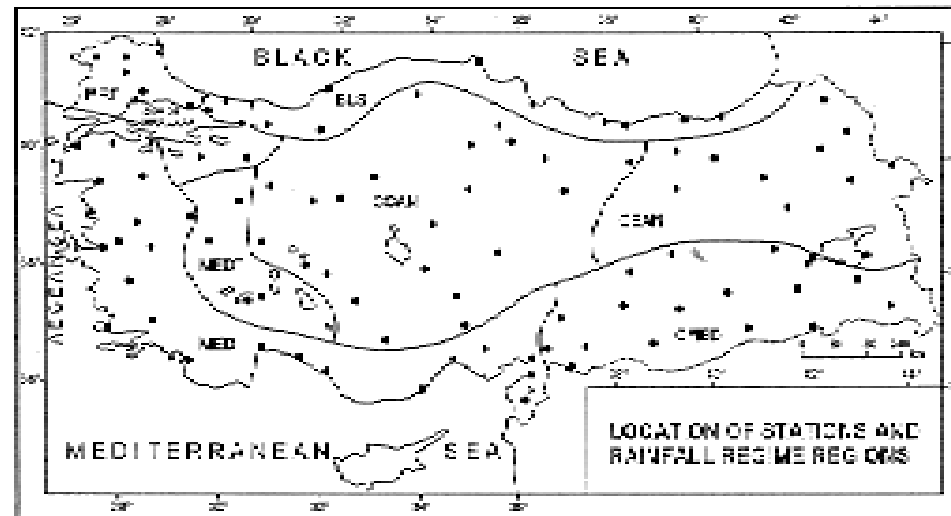


Figure 1. Location of the stations and rainfall regime regions of Turkey.

In this study, a normalized rainfall index was used. The normalized rainfall anomaly ( $A_{sy}$ ) for a given station is computed with

$$A_{sy} = (R_{sy} - \bar{R}_s) / \sigma_s$$

where  $R_{sy}$  is the rainfall total for the station  $s$  during a year (or a season), and  $\bar{R}_s$  and  $\sigma_s$  are the long-term mean and standard deviation of the annual (or seasonal) rainfall total for that station, respectively. Descriptions and classifications of the index are given in Table 2.

The area-averaged normalized rainfall anomaly ( $A_{ry}$ ) is defined as

$$A_{ry} = (1 / N_s) \sum_{s=1}^{N_s} A_{sy}$$

where  $N_s$  is the number of country-wide (or regional) stations operating in a year  $y$ .

The Eastern Black Sea and the Western Mediterranean coasts are the wettest areas of the country in winter, with a mean rainfall total of more than 650 mm. Approximately half of the country has less than 50 mm mean rainfall in summer, with a minimum of less than 5 mm along the Turkey–Syria

Limit of index	Character of rainfall
1.76 or more	Extremely above normal
1.31 to 1.75	Very much above normal
0.86 to 1.30	Much above normal
0.51 to 0.85	Above normal
0.50 to -0.50	Near normal
-0.51 to -0.85	Below normal
-0.86 to -1.30	Much below normal
-1.31 to -1.75	Very much below normal
-1.76 or less	Extremely below normal

Table 2. Normalized rainfall index.

border. Mean annual rainfall totals range from about 300 mm over continental central Anatolia to more than 1,000 mm along the Western Black Sea, Eastern Black Sea, and Western Mediterranean coasts (Figure 2). The highest mean annual rainfall total was recorded at the station of Rize on the Eastern Black Sea coast, with 2,304 mm. Over the continental Mediterranean region, mean annual rainfall increases from south (with about 400 mm) to north (with about 800 mm). The annual rainfall is more than 500 mm over a considerable part of the continental eastern Anatolia region, and it increases over mountains.

The coefficients of variation of 99 stations were computed to show the magnitude and spatial pattern of the interannual variability of rainfall totals over Turkey. The coefficient of variation ( $CV$ ) is defined as

$$CV = (\sigma_s / \bar{R}_s) \cdot 100 \text{ (per cent)}$$

where  $\bar{R}_s$  and  $\sigma_s$  are the long-term mean annual (or seasonal) rainfall and standard deviation of the annual (or seasonal) rainfall totals for a station  $s$ ,

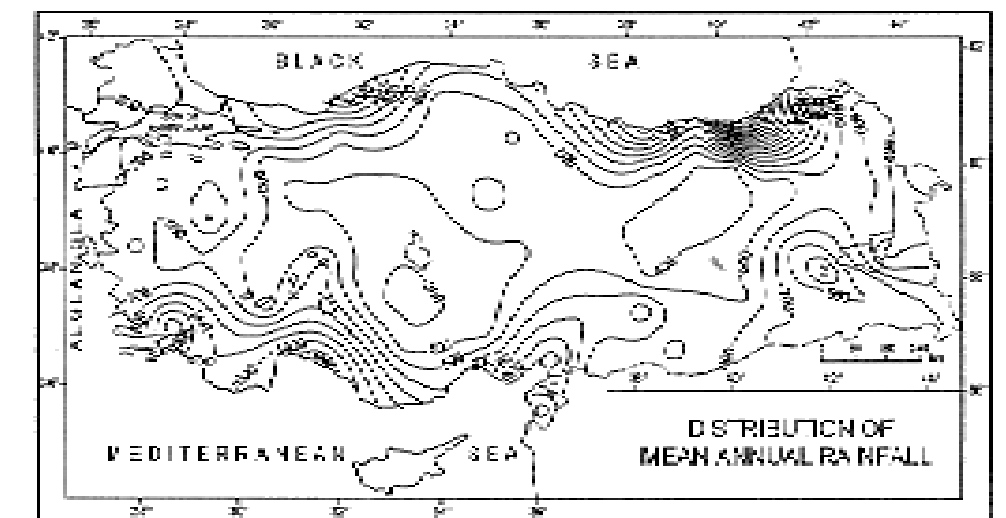


Figure 2. Spatial distribution of the mean annual rainfall totals over Turkey.

respectively. In winter, the CVs are considerably greater than 35% over most of Turkey. Variability of summer rainfall is generally greater than 80% over the Mediterranean and continental Mediterranean rainfall regions. The variability of annual rainfall decreases from the southern part of the country, with a seasonal rainfall regime, to the Black Sea coast, with a uniform rainfall regime (Figure 3). The CVs are well above 25% on the Mediterranean coast and over most of the continental Mediterranean region.

The time-series plot for Turkey shows a low-frequency fluctuation around a markedly decreasing mean. Normalized winter rainfall anomalies are generally characterized by two major wet periods, 1940–48 and 1962–70, and two major dry periods, 1971–74 and 1989–93 (Figure 4a). After a general run of wet conditions from 1935 to 1970, persistent dry conditions markedly dominated the period 1971–93. For this recent period, dry conditions reached two country-wide peaks of severity in 1973 and 1989. The driest year was 1973, with a negative anomaly of -1.50; the wettest year was 1963, with a positive anomaly of +1.80. Normalized annual rainfall anomalies of Turkey generally show three major wet periods—1935–44, 1962–69, and 1975–81—and three major dry periods—1955–61, 1970–74, and 1982–93 (except for two wetter years, 1987 and 1988) (Figure 4b). The driest year was 1932, with a negative anomaly of -1.40, while the wettest one was 1940, with a positive anomaly of +1.30.

When the dry conditions that dominated over the last 20 years are taken into account, it is observed that severe and widespread drought events occurred in 1973, 1984, 1989, and 1990. This situation is more evident for winter rainfall. The winter of 1973 was the driest one of the 64-year study period for many stations. Rainfall was generally below normal over most of Turkey (Figure 5a). Extremely low rainfall anomalies dominated over the continental central Anatolia, Mediterranean, and continental Mediterranean regions. In winter 1984, drier-than-normal conditions dominated over most

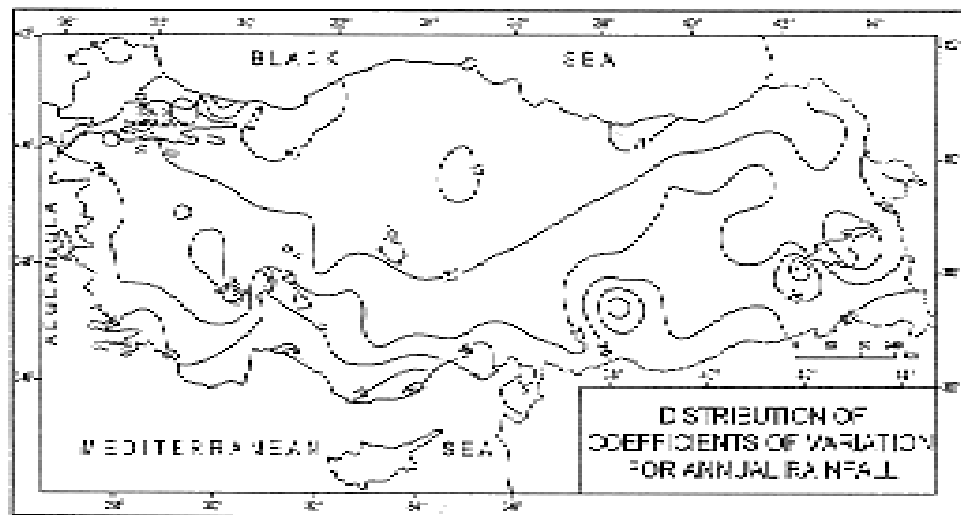


Figure 3. Spatial distribution of the coefficients of variation for annual rainfall over Turkey.

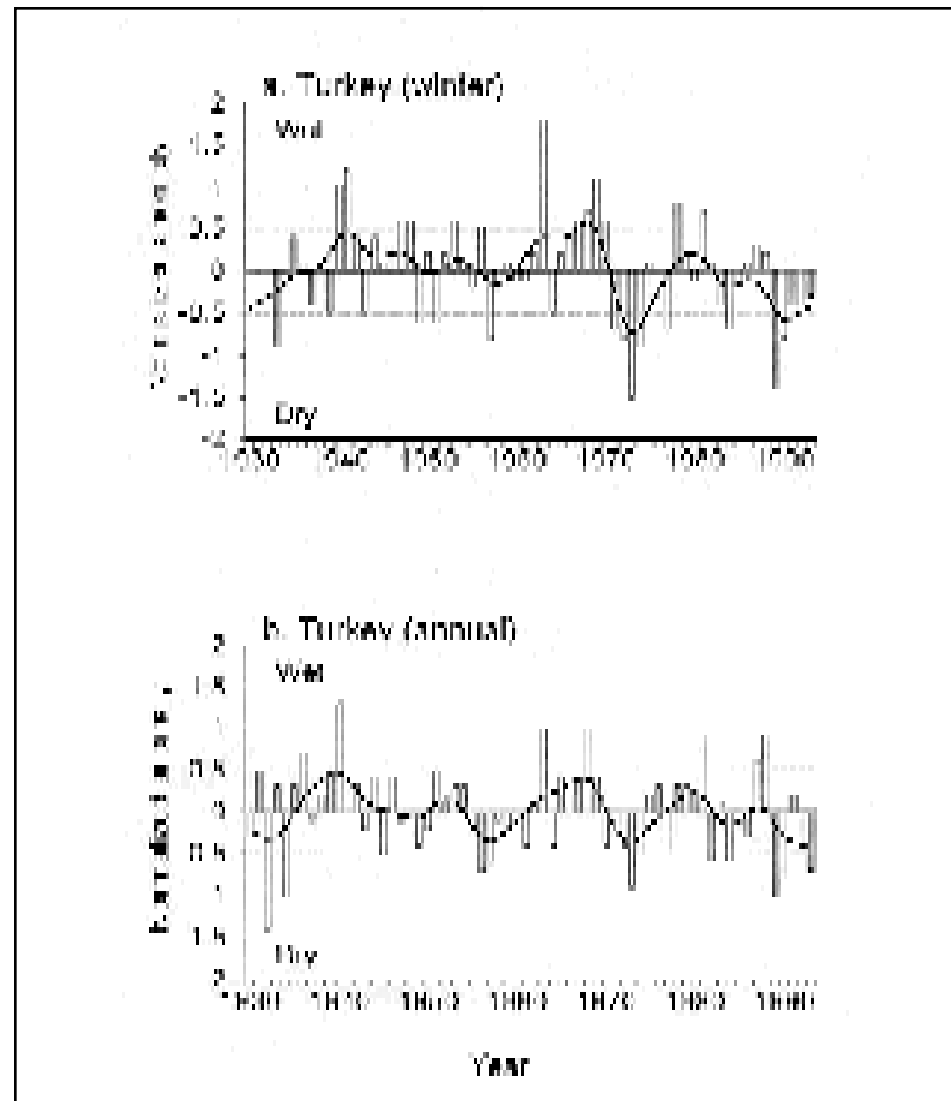


Figure 4. Variations in normalized (a) winter and (b) annual rainfall anomalies over all of Turkey. Normalized anomalies are smoothed by the nine-point Gaussian filter (—).

of the country, except the Mediterranean rainfall region (Figure 5b). Rainfall anomalies that were very much below normal were apparent particularly over the continental Mediterranean region and the continental interiors, along with the Eastern Black Sea subregion. The winter of 1989 was the second driest one of the study period for many stations. Areas with very much below normal rainfall covered most of Turkey, except the Black Sea coast and the southeast corner of the country (Figure 5c). Extremely low rainfall anomalies occurred generally over the continental central Anatolia, continental eastern Anatolia, and continental Mediterranean regions. Drier-than-normal conditions also persisted in the winter of 1990, throughout most of the western half of the country (Figure 5d). Extremely dry conditions affected the southwest portion of Anatolia.

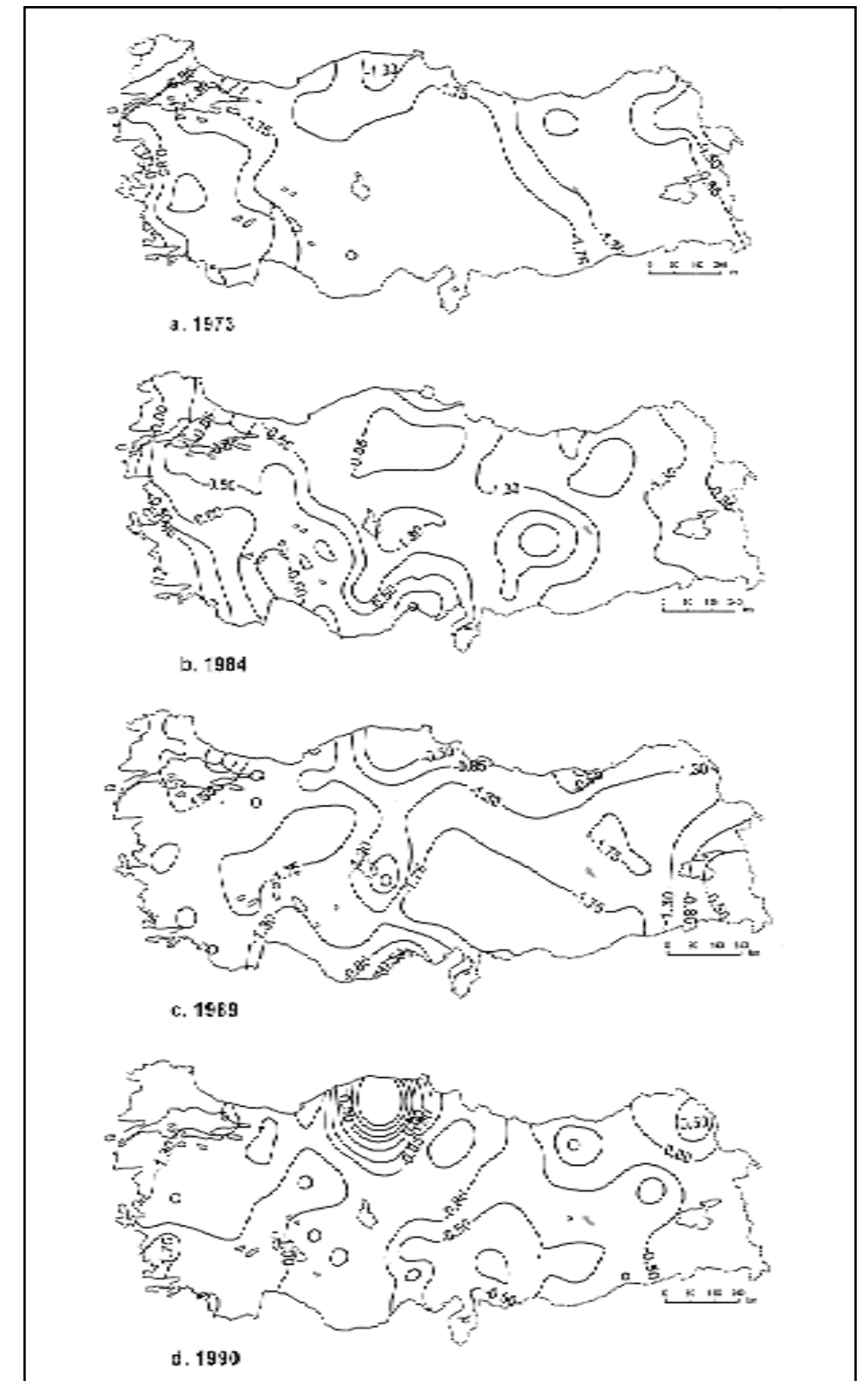


Figure 5. Spatial distribution of normalized rainfall index values over Turkey for winters of (a) 1973, (b) 1984, (c) 1989, and (d) 1990.

Taking into account the decreased number of depression activities and the general upward trend in the heights of 700 hPa geopotential level, we have concluded that anticyclonic circulation has affected Turkey more frequently during about the last 20 years (Türkeş, 1996c). Therefore, abrupt decreases in rainfall amounts from the early 1970s, particularly in winter, could be attributed to a possible further northward shift of the polar front from its normal position. This shift results from a more eastward extension of the drought-dominated subtropical anticyclones extending from the Azores to the eastern Mediterranean.

#### **References/Further Reading**

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