Drought Periods During XXth Centure In Bulgaria

Ekaterina Koleva, Vesselin Alexandrov, Nikola Slavov
National Institute of Meteorology and Hydrology
Sofia, Bulgaria

Abstract

Statistical methods were used in order to analyze the long-term variations of precipitation, air temperature. The long-term series of data were smoothed by averages and they were also approximated by means of a polynomial. These methods eliminate the random and short periodical fluctuations of the time series. The Spearman coefficient (r) and the Kendall coefficient (r₁) were used in order to investigate the existence of eventual trends.

Some quantitative criteria were also used for a comparison of the drought frequency and intensity between different regions and years.

Three periods can be determined during the 20th century, which are characterized by longer and severe droughts, namely 1902-1913, 1942-1953 and 1982-1994. During the period 1982-1994 the drought years were approximately 50 % of the total years. Another specific characteristic of the last period is that years with significant precipitation were not observed in South Bulgaria.

Key-words: drought indexes, precipitation, distribution, climate variability, regional estimation

The drought problem always exists somewhere in the world so that the economy of some nation or nations is always being adversely influenced by this factor. Although drought is a natural component of the climate in arid and semi-arid areas, it can occur in areas which normally receive adequate precipitation. Available hydrometeorological data indicate droughts have occurred through the last century in Bulgaria and they a part of the climatic cycle on the Balkan peninsula.

Annual precipitation in Bulgaria is ranging from 550-600 mm at the lowest areas in the country to 1000-1100 mm at the highest areas. The specific precipitation distribution in the country is due to the particular atmospheric conditions over the Bulgarian territory, which are considerably influenced by the orography. Insignificant precipitation amounts are among the common characteristics of climate in Bulgaria and they create a premise for an existence of a drought tendency in the country. According to the meanings of the Budyko drought coefficient (K), Bulgaria is characterized by insignificant moisture. This coefficient is calculated using data of annual radiation balance and total annual precipitation (Climatology, 1989). The Budyko drought coefficient is between 1.5 and 1.8 for Bulgaria.

The precipitation distribution is one of the basic characteristics of the drought occurrence in a given region. However, the distributions of additional meteorological elements should be also taken into account in order to describe the degree of the climate dryness. For example, the distribution of air temperature is an especially important characteristic for drought classifications. Usually, average precipitation for a given region is calculated under the analysis of the long-term variations of precipitation. Consequently, the index of anomaly is calculated (Koleva, 1988):

$$P_j = \frac{1}{n} \sum_{i=1}^{n} \frac{x_i}{\overline{\overline{x_i}}}$$

(1)

where: j = 1,..., N;   - total annual precipitation in the ith station,

$\overline{x_i}$ - averaged annual precipitation for the same station,

n – station number.

Figure 1 shows the long-term variations of annual precipitation and also seasonal precipitation for the period May-September. It can be seen that the decreasing trend of precipitation, observed during the last years of the 20th century is well presented. Statistical methods were used in order to analyze the long-term variations of precipitation and air temperature. The long-term series of data were smoothed by averages and they were also approximated by means of a polynomial. These methods eliminate the random and short periodical fluctuations of the time series. As the visual evaluation of the smoothed time series is usually a subjective method, the Spearman coefficient (r) and the Kendall coefficient (r₁) were used in order to investigate the existence of eventual trends (WMO, 1966, 1990).
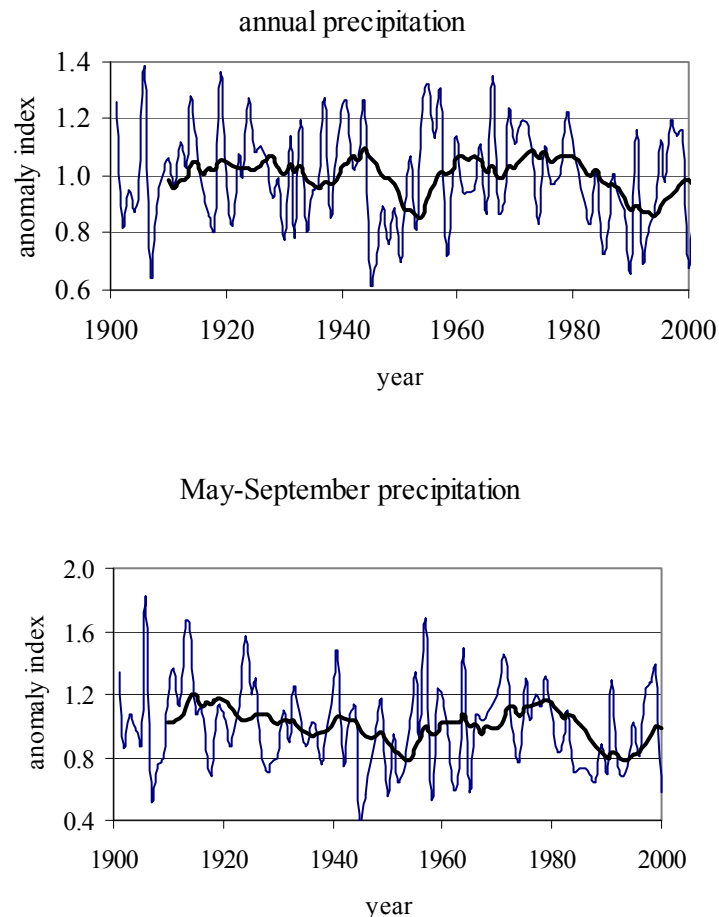
annual precipitation

May-September precipitation

Figure 1. Variation of precipitation anomaly index and 10-years moving average for North Bulgaria

Different quantitative criteria were also used for a comparison of the drought frequency and intensity between different regions and years. For example (Koleva, 1998) :

Ped index: $Ped = \dfrac{\Delta T}{\sigma_T} - \dfrac{\Delta P}{\sigma_P}$ (2)

where: ΔT and ΔP - anomalies of air temperature and precipitation, relative to a given time period;
   σ_T, σ_P - standard deviations of air temperature and precipitation.

The Ped index values between 1-2 show an existence of an insignificant drought, when 2 <*Ped*<3 – moderate drought, and when *Ped* > 3 – significant (severe) drought. The negative index values characterize a wet period. Droughts are more frequently in the Thracian Lowland, when the *Ped* values are higher than 2. Drought years during the last decade of the 20th century were 1989, 1990, 1992 and 1994. The last three years were especially dry, when the Ped values were higher than 3 and even 4. In general, there is an increasing trend of the *Ped* index (Fig. 2).

De Marton index: $J = \dfrac{\dfrac{P}{T+10} + \dfrac{12p}{t+10}}{2}$ (4)

where: P and T - total annual precipitation and annual air temperature,
   p –precipitation during the driest month of the year,
   t – air temperature during the warmest month of the year.

When the J index is less than 30, drought conditions can be observed and when it is less than 20 a severe drought can occur.
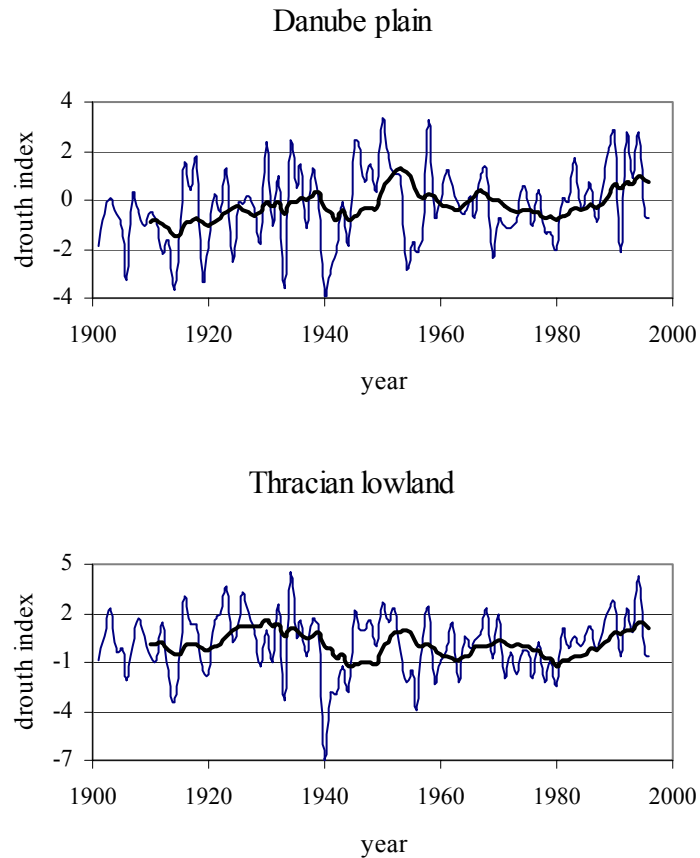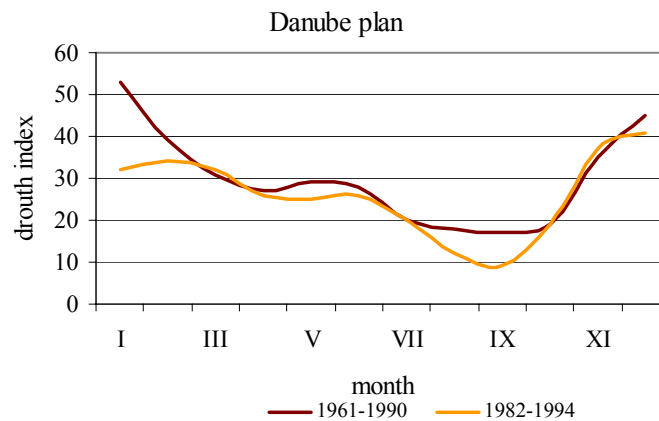
Danube plain

Thracian lowland

Figure 2. Annual Ped index and its smoothed average for Danube Plain and Thracian Lowland

The average values of the *J* index were about 25 in different regions during the period 1961-1990. It decreased down to 19-23 during the period 1982-1994. Figure 3 shows the variations of the *J* index for every month of the year, regarding these two periods. July, August and September are the driest months when the *J* index has values about 10.
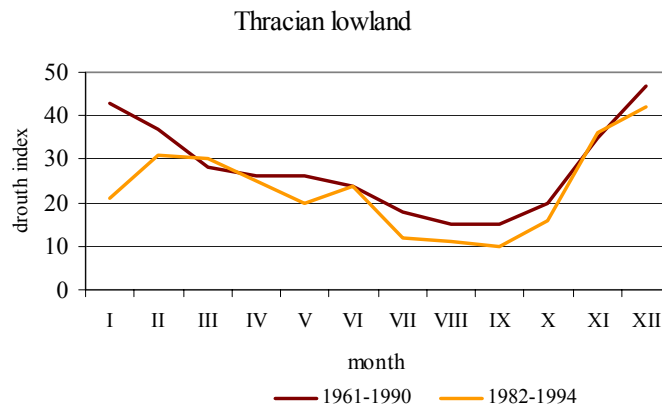
Danube plan

Thracian lowland

Figure 3 Marton index for Danube Plain and Thracian Lowland

As a result of the conducted analysis, the investigated period can be divided to separate sub-periods with duration of 10-15 years. These years are characterized with different moisture conditions. The following criteria were used in order to determine these moisture conditions:

$$P < \overline{P} - 2\sigma_P \qquad \text{- severe drought}$$

$$\overline{P} - 2\sigma_P < P < \overline{P} - \sigma_P \qquad - \qquad \text{drought} \qquad\qquad (5)$$

$$\overline{P} - \sigma_P < P < \overline{P} + \sigma_P \qquad - \qquad \text{normal}$$

$$P > \overline{P} + \sigma_P \qquad - \qquad \text{wet}$$

where: P – precipitation in a particular year,

   $\overline{P}$ - average precipitation during the period 1961-1990,

   σ_P - standard deviation.

The distribution of the years according these criteria is presented in Figure 4.
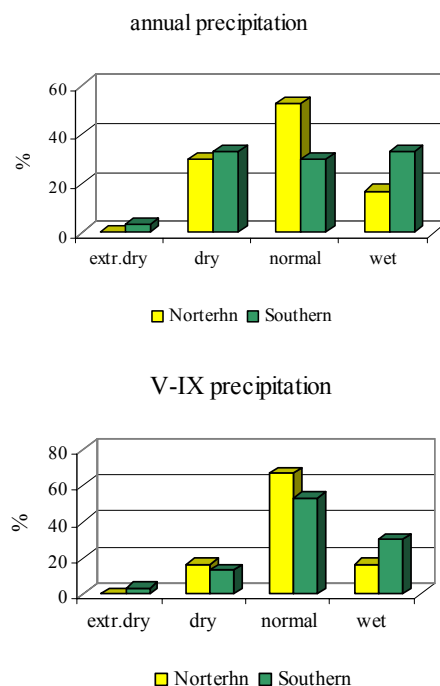
annual precipitation

V-IX precipitation

Figure 4. Distribution (%) of extremely dry, dry, normal and wet years for period 1961-1990

Three periods can be determined during the 20th century, which are characterized by longer and severe droughts, namely 1902-1913, 1942-1953 and 1982-1994. The drought years were approximately 20% of the total years during the first period. On the other hand, they increased till 40 % during the second period and even during the period 1982-1994 they were approximately 50 %. Another specific characteristic of the last period is that years with significant precipitation were not observed in South Bulgaria (Fig.5). Average precipitation in the Danube Plain was about 560 mm and it was 540 mm in the Tracian Lowland. Precipitation during the period May-September was 280 and 230 mm, respectively. The coefficient of variation (CV) in the two regions was about 0.25-0.35, which shows insignificant moisture resources or a dry climate.
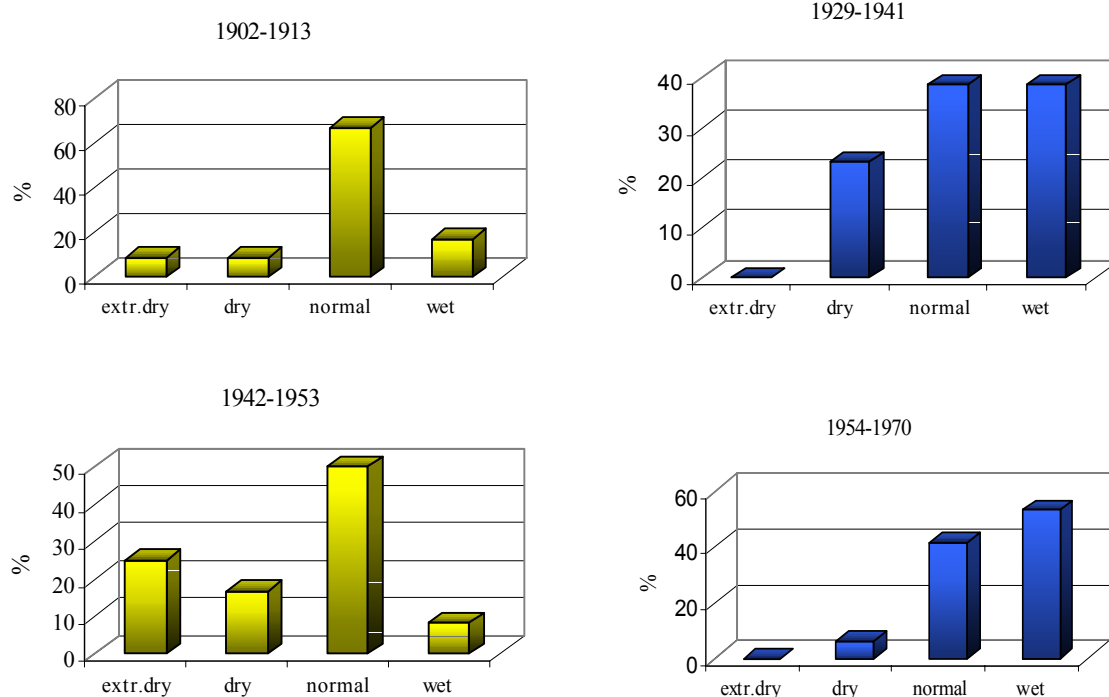

Figure 5. Distribution (%) of extremely dry, dry, normal and wet years for North Bulgaria

The driest year during the investigated period of the 20th century (1901-1996) was 1945. Among the considerably dry years were also 1902, 1907, 1932, 1934, 1946, 1948, 1950, 1953, 1985, 1986, 1990, 1992 and 1993. It is necessary to remark that there are some differences in the classification of the dry years, regarding the regions of North and Sought Bulgaria.

Figure 6 represents the interannual distribution of precipitation during the periods 1961-1990, 1942-1953 and 1982-1994. It can be seen that during the period 1942-1953 drought conditions were observed at the end of summer and at the beginning of autumn when precipitation is 10-20 mm less than the normals. The precipitation amounts were especially insignificant during the winters of the period 1982-1994. The characteristics of the precipitation distribution during the above time periods were similar to the characteristics of the moderate-continental distribution of precipitation. The precipitation distribution in the country for the periods 1961-1990 and 1982-1994 is shown in Figure 6.
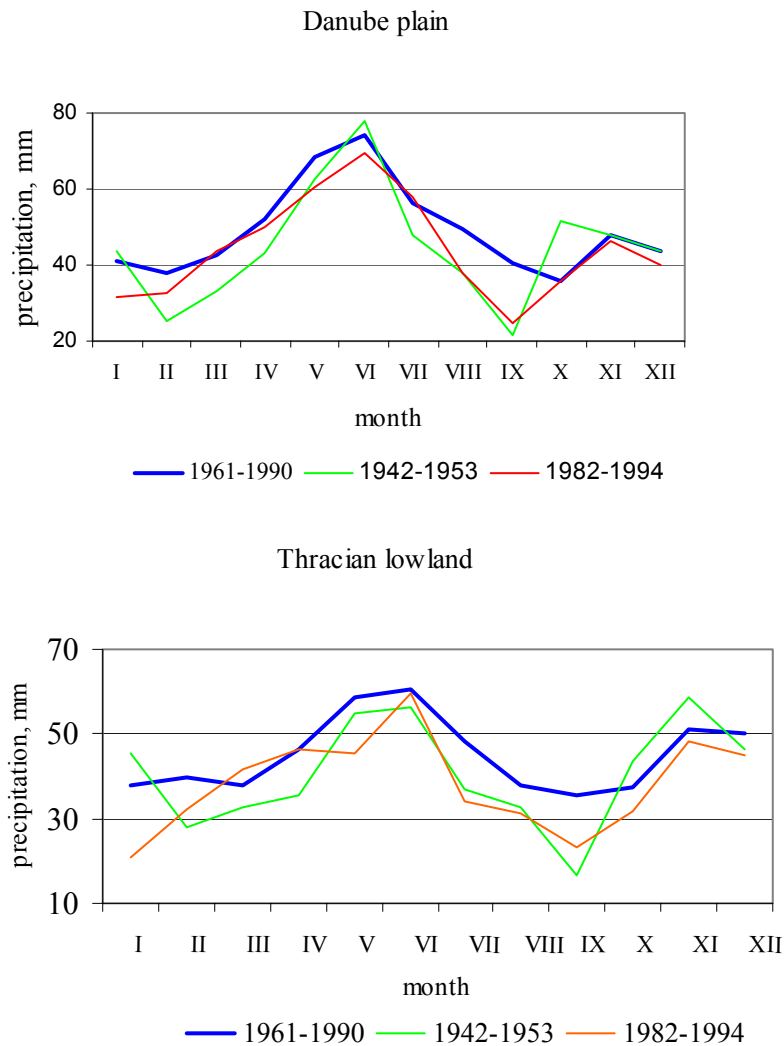
Danube plain

Thracian lowland

Figure 6. Monthly precipitation distribution

Particular years, months or subsequent months with insignificant precipitation, i.e. periods of atmospheric drought, are not seldom events in the country and they can be considered as a normal climate characteristic in Bulgaria. Climatically, about two subsequent dry months occur in the lower areas of the country. However, there are some years with six and more subsequent dry months. Long dry periods during the cold-half of the year were observed in 1913, 1934 1967, 1976 and 1983. Similar periods during the warm-half of the year occurred in 1928, 1945, 1965 and 1985.

Climatically, there are three subsequent months during the year with precipitation below normals and the total months with precipitation below normals throughout the year is about five. Usually, precipitation is less than 50% of the normals in two-three months during the year. In some particular years, 5-6 or even more subsequent months with less precipitation than the normals can be observed. These cases occurred about 25-30 % of the years during the period 1906-1996. Precipitation was especially reduced from January to November, 1945 in the most country regions. Taking into account that the autumn in 1944 was also dry, a severe long drought was observed in the 1940s – the drought duration was approximately 12-15 months. Several subsequent dry months (from January to August, even at some places till October) were also observed in 1938, 1959 and 1968. Precipitation was in some months 20-30% lower than the normal. These drought episodes however were not observed in all regions in Bulgaria. There were from four to six subsequent months with reduced precipitation in 1985, 1990, 1992, 1993 and 1994. The total months with lower precipitation tnan the normals in some weather stations were about nine-ten. In these years precipitation was 50% less than the normals in four to six months. Even in some weather stations such as Lom, Stara Zagora and Sliven the dry months were between seven and nine.

It is necessary to emphasize that during the 20th century there was no year with monthly precipitation above the normals only and vise versa. There were always some subsequent wet months even during the most drought years in Bulgaria.

Reference

Climatology (1989) *Gidrometeoizdat, Leningrad, Russia, 568 pp (In Russian).*

Koleva, Ek. (1988) *Some features of the precipitation distribution in the lowers areas in Bulgaria. Problems of Meteorology and Hydrology, No.2, pp. 41-48 (In Bulgarian)*

Koleva, Ek. (1991) *Precipitation distribution. In: Climate in Bulgaria, Bulgarian Academy of Sciences, Sofia, Bulgaria, 499 pp (In Bulgarian).*

Koleva Ek. (1995) *Drought in the Lower Danube Basin. Drought Network News. Vol. 7, No 1, Feb., Nebraska, USA, 6-7.*

Koleva Ek., C. Boroneant, E. Bruci (1998) *Study on the variability of annual and seasonal precipitation over the Balkan Peninsula. The second International Conference on the Climate and Water, Esoo, Finland 17-20 August, vol. 3, 1084-1089*

Sharov, V. N.Slavov, Ek. Koleva, P. Ivanov, Em.Moralijski, L.Latinov, S. Dakova, An. Gocheva, R.Peneva and V. Alexandrov, 1994. Drought in Bulgaria. Scientific report on the contract NI-NZ-19/1991, Scientific fond "Scientific investigations", Ministry of education and science, 65 pp (In Bulgarian).

WMO (1966), Climate change. Technical Note 9, Geneva.

WMO (1990) On the statistical analysis of series of observations. Technical Note 143, Geneva.