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CLIMATE VARIABILITY AND ITS INFLUENCE ON GROUNDWATER IN CENTRAL BULGARIA DURING THE LAST DECADES

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Introduction. The fields for mean monthly air temperature and precipitation are studied for the period 1961–2000 for the whole territory of the country. The behaviour of the curves characterising the change of the temperature and precipitation anomalies is analysed by physical-statistical methods.

The groundwater regime is presented by time series of discharge for springs and groundwater level in wells. Observational stations were chosen without significant impact of human activity.

Utilised data. The mean temperatures from 8 stations on the territory of Bulgaria (in this number for the cities of Pleven and Plovdiv) for the period 1961–2000 have been used as initial data.

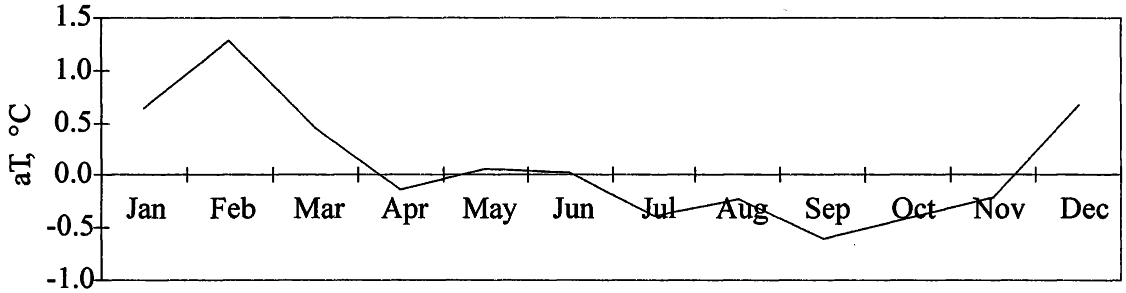
The data of daily surface pressure fields over Bulgaria received at 00:00 GMT covering the period from 1.01.1986 to 31.12.1995 was used.

The geopotential field at 500 hPa level for the period December 1993 till February 1994 was used.

Hydrogeological data: time-series (1961–2000) of discharge for karstic springs (G. Zheljazna—N 24a near Pleven and Tri Voditzi—N 65 near Plovdiv) and water level for observational wells (Tulovo—N 271).

Some trends of the climatic variability in Bulgaria during the period 1961–2000. PECULIARITIES OF THE TEMPERATURE REGIME. The trend of alternation of long periods with different signs of the temperature anomalies (aT, °C) is especially well expressed on the curves (Fig. 1). A period of climatic warming in the country is the winter. For the Black Sea side there is a second maximum of temperature in April. It is respectively like the result of the transformation of the air masses near the sea. One can note that a long period of warm winters has been prevailing since 1961 till now.

For the decade 1986–95 (Fig. 2) the months of the winter are periods of positive anomalies. Strongly expressed maxima are observed in 1986, 1989, 1993, 1994 (January aT > 3 °C), 1988, 1989, 1990, 1995 (February aT > 3 °C), 1986, 1989, 1993 (December aT > 3 °C) and the rest of the years mark weakly expressed ones with the exception of February in 1986. Winter is the season of climatic warming in the country during the long period. The averaged temperatures were for the most part of the years above



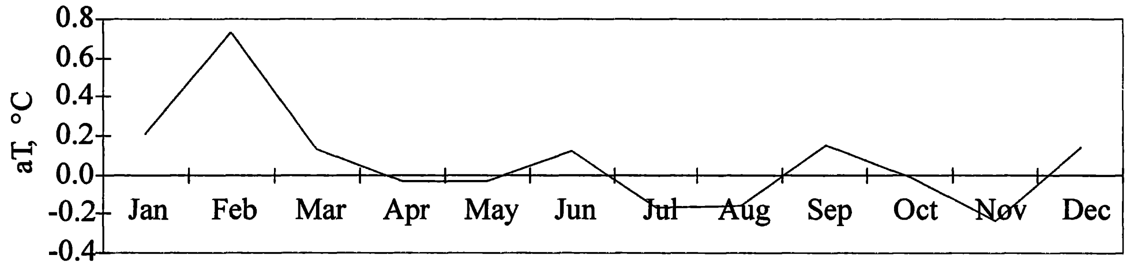


Fig. 1. Monthly trend of temperature anomaly for the period 1961–2000

the norm. During the last decade a well-defined trend towards temperature increase in the country dominates.

In spring the average values of the temperatures remain about the norm. The behaviour of the curve characterising the change of the mean temperature in summer is different. The averaged aT curve is a part of a wavy-like character with weakly expressed minima in July. A well-expressed trend to weather cooling in Bulgaria occurs in summer. The summer was cool for the whole country. For the decade 1986–1995 (Fig. 2) the seasonal and monthly mean temperatures were about and above norm, especially in August. At the Black Sea side the temperature remained below norm. The reason for this temperature deviation was in the peculiarities of the surface-pressure field.

During the summer months the baric gradient decreases over Europe and for a long time from May to September there are no dynamic changes in the atmospheric processes. In summer over the Continent the thermal depression is formed.

In autumn, one can say that from the beginning of the period till 1995 a long interval of negative anomalies of the autumn temperature prevails.

Spatial-temporal distribution of the large anomalies of temperature. The large anomalies of the mean monthly values of the air temperatures at ground level are possible for the whole territory of Bulgaria (Fig. 3). During the period of October-November the autumnal-winter atmospheric circulation begins and the values of the negative anomalies decrease. In November a strong minimum temperature is expressed and it is observed all over Bulgaria, as a result of better definite cyclonic activity (Fig. 4).

For the cold period of the year the amount of positive and negative anomalies is approximately equal, i.e. the positives large anomalies and the negative ones are with similar frequencies.

The large negative anomaly is closely related to the high cyclones and Lows, and

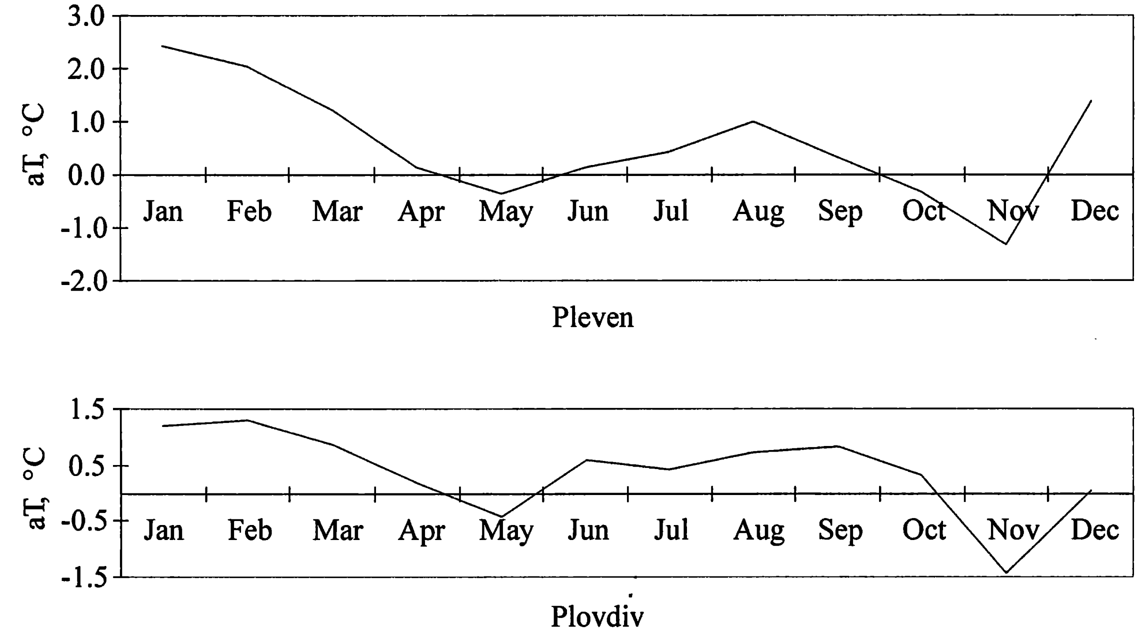


Fig. 2. Monthly trend of temperature anomaly for the period 1986–1995

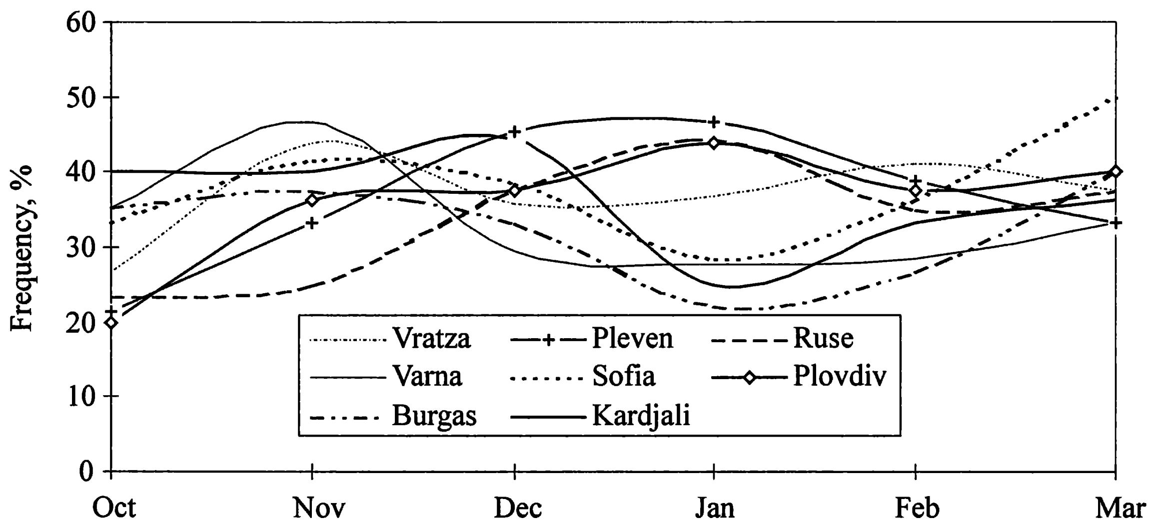


Fig. 3. Frequency of the large monthly temperature anomalies

is not observed under areas with high anticyclones. The large positive anomalies are usually related to the Highs.

PRESSURE PATTERNS. The annual course (Fig. 4) of the baric relief over Bulgaria was investigated in isolation for both baric forms: the anticyclonic form (with surface pressure above 1015 Mb) and the cyclonic were obtained for the period 1986–95. The anticyclonic baric relief predominates—the average of 61% in all days of the period is with anticyclonic relief; the cyclonic baric relief is 39% in the rest of the days. The year is divided into two unequal parts, first—from May till September, and a second one—includes the months from October till April. The basic motive for this division is equal for the period May till September of two forms of baric relief, the cyclonic and anticyclonic. During the cold part of the year, the anticyclonic baric relief considerably

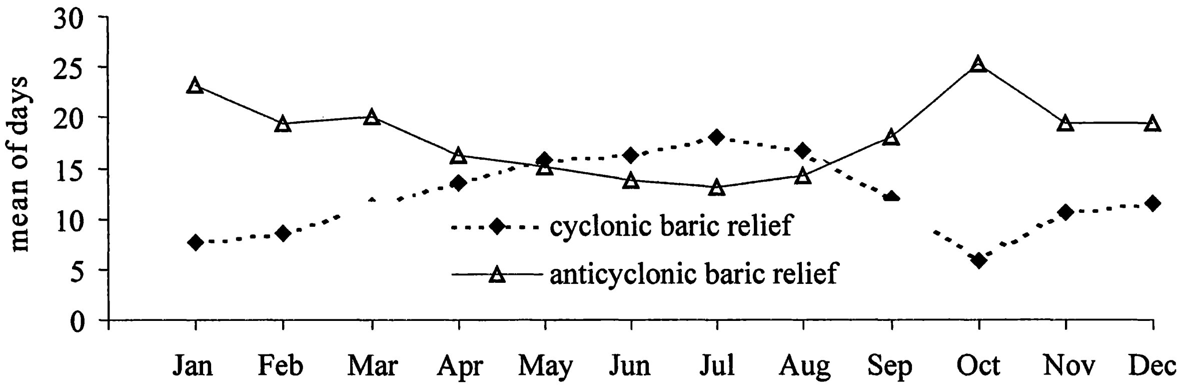


Fig. 4. Annual course of cyclonic and anticyclonic baric relief

goes beyond the cyclonic one; and during the warm part—the cyclonic, although better represented, does not differ particularly from the anticyclonic. The probabilities are also obtained considerably over the normal anticyclonality of the baric field on the ground level during the cold months.

The winter 1993–94 was a period characterised by strongly anomalous circulation over Europe. The circulation for this period was well presented on the charts of the geopotential field at 500 hPa level. The geopotential time variability for the studied period was expressed by integral curves of their daily anomalies. To draw the integral curves, three points from the Scandinavian region are selected and are indicated in Fig. 5 for December 1993 till February 1994.

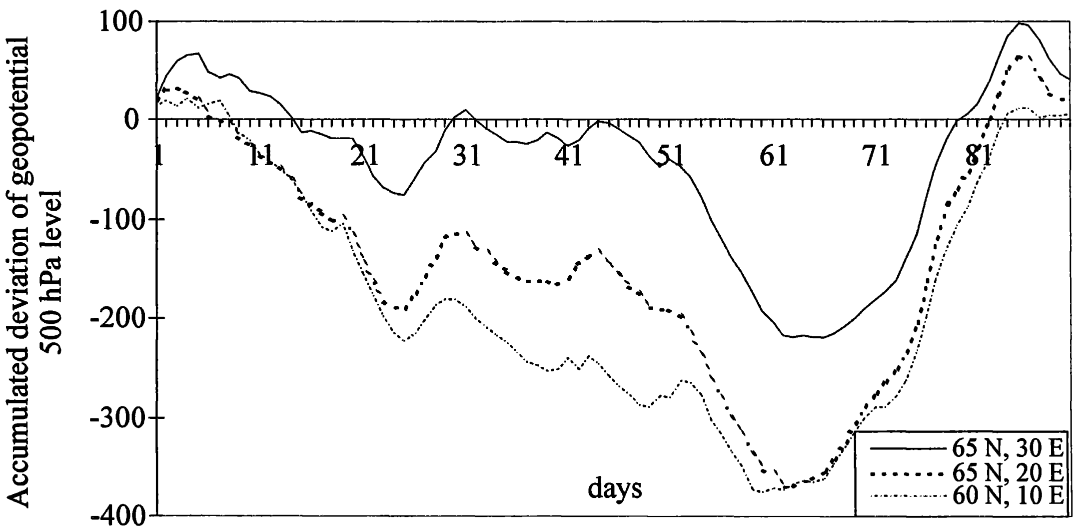


Fig. 5. Integral curve

Climatic variability of precipitation. Regional precipitation amount is one of the major components of Bulgaria's water budget. Precipitation climatic variability estimated for the country is of great interest as temperature data [1,3]. In the whole country in the period May-September precipitation anomalies averaged and for the last decade 1986–1995 were generally lower than the estimated norm.

Natural variations in groundwater regime in Bulgaria were analysed. The chosen karstic springs and the wells observed were without evident human impact. The basic recharge to groundwater occurs in spring due to snow melting. Most of the karstic springs in northern Bulgaria have immediate response to change in effective precipitation. Some other springs with larger regulating capacity have more smooth reaction.

During the cold period of the year the losses to evapotranspiration are insignificant, and almost all precipitation goes to recharge to groundwater and river runoff. So, the reduction in winter precipitation has strong negative impact on groundwater recharge. This was the case during the drought period in Bulgaria.

The climate variability during the recent drought period influenced considerably upon the groundwater regime in Bulgaria. Most karstic springs have reduced discharge (20–30% on average) and the wells show lowering of the water level (0.3–0.4 m) [5-7]. This is illustrated in Figs 6–7.

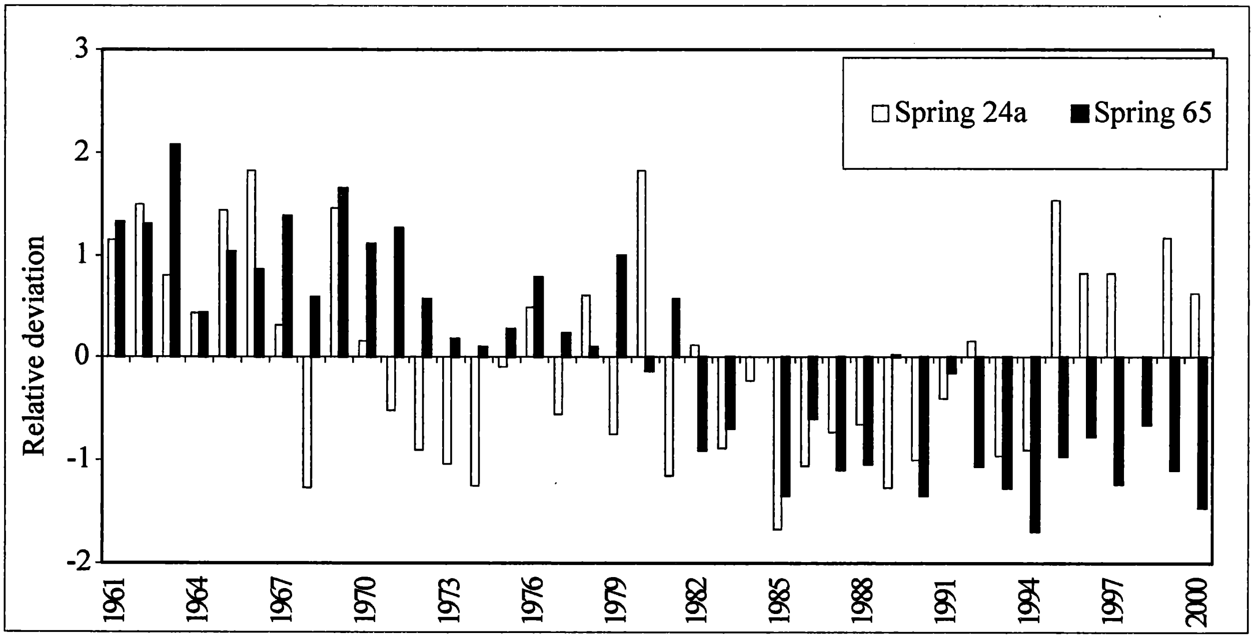


Fig. 6. Discharge for karstic springs in relative deviations

Conclusion. For the decade (1986–1995):

- There is tendency to positive anomalies of the air temperature to increase during winter. We can note the tendency for dry period for the whole territory of the country and particularly during the warm part of the year.

- The probabilities are obtained considerably over normal anticyclonality of the baric field on the ground level during the cold months (October-April).

- The synoptic processes over the Scandinavian region and the determination of the blocking processes are of significant importance for the definition of the periods of extreme processes over the Balkans and particularly for Bulgaria.

- The climatic variability during the drought period influenced considerably the groundwater regime in Bulgaria. Most karstic springs had reduced discharge and observational wells showed lowering of the water level due to a decrease in the recharge to the groundwater.

- The reduction of winter precipitation during the drought period in Bulgaria had strong negative influence on the groundwater recharge.

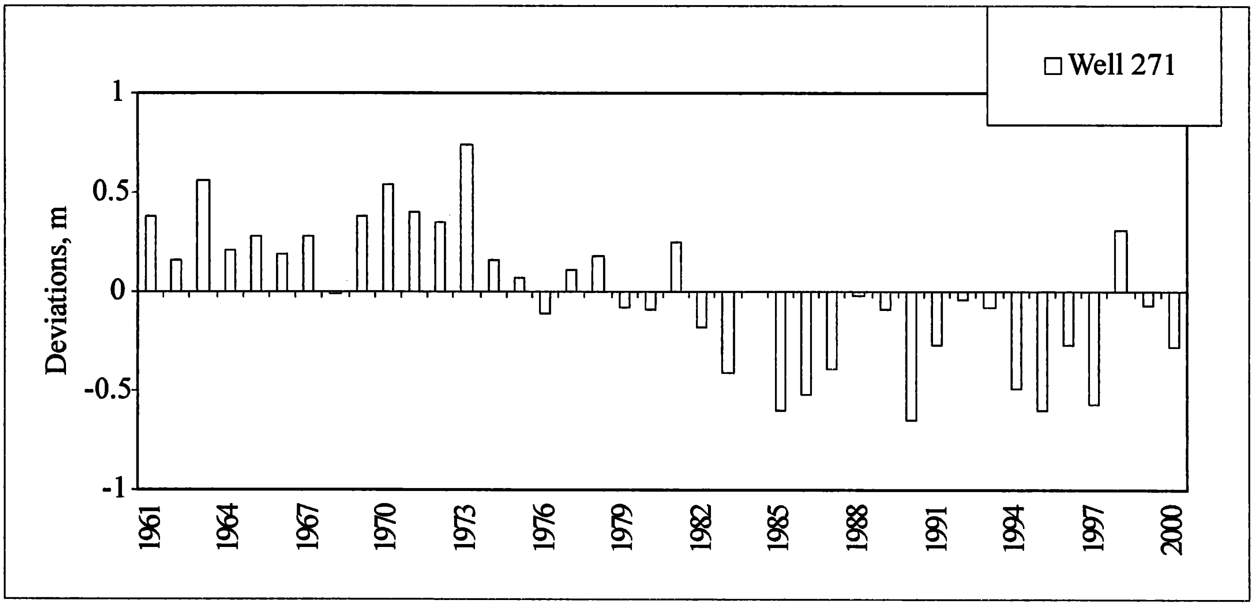


Fig. 7. Variation of water level for well 271 in absolute deviations

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