# SUPPLEMENTS TO THE CATEGORIES OF CONTEMPORANEOUS TEMPERATURE AND PRECIPITATION ANOMALIES IN HUNGARY AND TO THEIR STATISTIC ANALYSIS

by

*L. Makra*

*Adalékok egyidejű hőmérséklet- és csapadékanomáliák magyarországi kategóriáihoz és azok statisztikai elemzéséhez.* Jelen tanulmány célja Magyarország területére egyidejű hőmérséklet- és csapadékanomáliák kategóriáinak megalkotása, s azok egymáshoz kapcsolódása mértékének statisztikai elemzése.

Az egyes kategóriák havi gyakorisági értékei eltérőknek mutatkoztak; a kategóriák ismétlődési tartamának gyakorisági eloszlása, csakúgy mint az ismétlődések átlagos hosszúsága egymástól független események következményeiként adódtak.

The aim of present study is creating weather categories on the basis of contemporaneous temperature and precipitation anomalies occurring in Hungary, and a statistic analysis of their rate of connection.

The monthly frequency of the single categories seemed to be different; the frequency distribution of the recurrence period of the categories as well as the average length of the recurrences followed as the consequences of unrelated events.

In present study data for processing was supplied by the areal average values of yearly and monthly precipitation at ten meteorological stations in Hungary (Szombathely, Keszthely, Magyaróvár, Pécs, Kalocsa, Budapest, Szeged, Eger, Túrkeve, Nyíregyháza, Table 1) [1] and territorial averages of monthly and yearly mean temperature time series observed at six stations (Keszthely, Magyaróvár, Pécs, Budapest, Szeged, Debrecen, Table 2). The time series refer to 110 years between 1871 and 1980, containing in this way data from 1320 months.

Geographical coordinates ($\varphi$, $\lambda$) and heights above sea level ($h$) of observing stations are as follows:

| | | ($\varphi$) | ($\lambda$) | ($h$) |
|---|---|---|---|---|
| 1. | Szombathely | 16°36′ | 47°15′ | 215 |
| 2. | Keszthely | 17°14′ | 46°45′ | 128 |
| 3. | Magyaróvár | 17°16′ | 47°53′ | 122 |
| 4. | Pécs | 18°12′ | 46°04′ | 123 |
| 5. | Kalocsa | 18°59′ | 46°32′ | 96 |
| 6. | Budapest | 19°02′ | 47°31′ | 118 |
| 7. | Szeged | 20°09′ | 46°15′ | 74 |
| 8. | Eger | 20°23′ | 47°53′ | 173 |
| 9. | Turkeve | 20°45′ | 47°07′ | 88 |
| 10. | Debrecen | 21°37′ | 47°33′ | 123 |
| 11. | Nyíregyháza | 21°41′ | 47°59′ | 105 |

Deviations from the average, that is to say anomalies were attached to each of the time series, i. e. wet and dry, warm and cold periods were discerned according to deviations from the average. Considering the number of alternative elementary

*Table 1*

(Statistical characteristics of regional averages made from monthly and annual precipitation amounts (mean ($\bar{x}$), standard deviation ($\sigma$)), Hungary, 1871—1980.

| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | *Year* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 33,691 | 32,136 | 37,591 | 51,409 | 66,027 | 74,855 | 65,800 | 61,046 | 49,700 | 54,173 | 53,273 | 44,064 | 623,927 |
| $\sigma$ | 16,015 | 19,279 | 19,691 | 23,673 | 26,757 | 25,934 | 27,429 | 26,873 | 24,896 | 32,856 | 29,090 | 20,853 | 89,889 |

*Table 2*

Statistical characteristics of regional averages made from monthly and annual mean temperatures (mean ($\bar{x}$), standard deviation ($\sigma$)), Hungary, 1871—1980.

| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | *Year* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | −1,579 | 0,450 | 5,359 | 10,821 | 15,730 | 19,183 | 21,173 | 20,408 | 16,447 | 10,960 | 5,044 | 0,536 | 10,358 |
| $\sigma$ | 2,854 | 2,837 | 2,191 | 1.662 | 1,663 | 1,335 | 1,259 | 1,279 | 1,526 | 1,721 | 2,053 | 2,483 | 0,693 |

*Table 3*

*Anomaly Categories (1871—1980)*
*wet-warm (1), wet-cold (2), dry-warm (3), dry-cold (4)*

| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | *Year* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1871 | 2 | 4 | 1 | 4 | 4 | 2 | 3 | 3 | 3 | 2 | 2 | 4 | 4 |
| 1872 | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 2 | 1 | 1 | 1 | 3 | 1 |
| 1873 | 1 | 1 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 4 | 3 |
| 1874 | 4 | 4 | 4 | 3 | 2 | 1 | 3 | 2 | 3 | 3 | 4 | 1 | 4 |
| 1875 | 3 | 4 | 4 | 4 | 3 | 1 | 1 | 3 | 4 | 2 | 2 | 4 | 4 |
| 1876 | 4 | 2 | 1 | 3 | 2 | 1 | 4 | 3 | 2 | 3 | 4 | 1 | 2 |
| 1877 | 3 | 1 | 2 | 2 | 2 | 3 | 2 | 3 | 2 | 4 | 3 | 2 | 4 |
| 1878 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 2 | 1 |
| 1879 | 2 | 1 | 4 | 2 | 2 | 1 | 2 | 3 | 1 | 2 | 4 | 4 | 2 |
| 1880 | 4 | 4 | 4 | 3 | 2 | 4 | 3 | 2 | 1 | 1 | 1 | 3 | 2 |
| 1881 | 2 | 4 | 2 | 2 | 2 | 2 | 3 | 1 | 2 | 2 | 4 | 4 | 2 |
| 1882 | 3 | 3 | 3 | 3 | 4 | 4 | 1 | 2 | 1 | 1 | 1 | 1 | 1 |
| 1883 | 1 | 3 | 2 | 4 | 4 | 1 | 1 | 4 | 2 | 1 | 2 | 4 | 2 |
| 1884 | 3 | 3 | 3 | 2 | 3 | 2 | 1 | 2 | 4 | 2 | 4 | 1 | 4 |
| 1885 | 4 | 3 | 3 | 3 | 2 | 3 | 1 | 2 | 3 | 1 | 3 | 4 | 3 |
| 1886 | 1 | 4 | 4 | 1 | 3 | 2 | 4 | 3 | 3 | 1 | 3 | 1 | 3 |
| 1887 | 4 | 4 | 2 | 4 | 2 | 4 | 3 | 4 | 3 | 2 | 1 | 2 | 4 |
| 1888 | 4 | 2 | 4 | 2 | 3 | 1 | 2 | 2 | 3 | 2 | 4 | 4 | 4 |
| 1889 | 4 | 2 | 2 | 2 | 3 | 3 | 1 | 4 | 2 | 1 | 4 | 4 | 2 |
| 1890 | 1 | 4 | 3 | 1 | 3 | 4 | 3 | 3 | 4 | 2 | 1 | 4 | 4 |
| 1891 | 2 | 4 | 2 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 3 | 2 |
| 1892 | 2 | 1 | 2 | 1 | 1 | 1 | 4 | 3 | 1 | 1 | 4 | 4 | 2 |
| 1893 | 2 | 1 | 4 | 4 | 4 | 2 | 2 | 4 | 4 | 3 | 2 | 3 | 2 |
| 1894 | 4 | 3 | 3 | 1 | 1 | 4 | 3 | 3 | 4 | 1 | 4 | 4 | 3 |
| 1895 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 3 | 2 | 3 | 2 | 2 |
| 1896 | 4 | 4 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 2 | 3 | 2 |
| 1897 | 1 | 3 | 1 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 4 | 4 | 2 |
| 1898 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 3 | 4 | 1 | 3 | 3 | 3 |
| 1899 | 1 | 3 | 4 | 3 | 2 | 4 | 2 | 4 | 2 | 4 | 3 | 2 | 2 |
| 1900 | 1 | 1 | 2 | 4 | 2 | 1 | 1 | 2 | 3 | 1 | 1 | 3 | 1 |
| 1901 | 4 | 4 | 1 | 1 | 3 | 3 | 1 | 2 | 2 | 3 | 4 | 3 | 2 |
| 1902 | 3 | 1 | 2 | 4 | 2 | 2 | 2 | 3 | 4 | 2 | 4 | 4 | 2 |
| 1903 | 4 | 3 | 3 | 2 | 4 | 2 | 2 | 4 | 1 | 3 | 1 | 1 | 1 |
| 1904 | 4 | 1 | 1 | 3 | 4 | 3 | 3 | 3 | 2 | 1 | 4 | 3 | 3 |
| 1905 | 4 | 3 | 3 | 2 | 2 | 1 | 3 | 3 | 1 | 2 | 1 | 3 | 1 |
| 1906 | 1 | 1 | 1 | 3 | 3 | 2 | 2 | 4 | 2 | 4 | 3 | 2 | 1 |
| 1907 | 2 | 4 | 4 | 2 | 3 | 3 | 2 | 4 | 4 | 3 | 4 | 1 | 4 |
| 1908 | 4 | 1 | 2 | 2 | 3 | 3 | 4 | 2 | 4 | 4 | 4 | 4 | 4 |
| 1909 | 4 | 4 | 2 | 3 | 2 | 4 | 4 | 1 | 1 | 3 | 4 | 1 | 4 |
| 1910 | 1 | 1 | 3 | 2 | 2 | 1 | 4 | 4 | 2 | 3 | 2 | 3 | 1 |
| 1911 | 3 | 4 | 3 | 4 | 2 | 4 | 3 | 3 | 3 | 1 | 3 | 3 | 3 |
| 1912 | 2 | 1 | 1 | 2 | 2 | 3 | 4 | 2 | 2 | 4 | 4 | 3 | 2 |
| 1913 | 4 | 4 | 3 | 4 | 2 | 4 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| 1914 | 4 | 4 | 1 | 3 | 2 | 2 | 2 | 4 | 2 | 4 | 4 | 1 | 2 |
| 1915 | 1 | 1 | 2 | 4 | 3 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 2 |
| 1916 | 3 | 1 | 1 | 2 | 3 | 4 | 4 | 4 | 2 | 4 | 3 | 1 | 1 |
| 1917 | 1 | 4 | 2 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 4 |
| 1918 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 2 | 1 | 1 | 2 | 1 | 3 |
| 1919 | 1 | 1 | 1 | 2 | 2 | 4 | 2 | 4 | 3 | 4 | 2 | 1 | 2 |
| 1920 | 1 | 3 | 3 | 3 | 3 | 2 | 1 | 4 | 3 | 4 | 4 | 1 | 3 |
| 1921 | 3 | 1 | 3 | 4 | 3 | 4 | 3 | 1 | 4 | 3 | 2 | 4 | 3 |
| 1922 | 2 | 4 | 1 | 2 | 3 | 3 | 4 | 4 | 2 | 2 | 4 | 3 | 2 |
| 1923 | 3 | 1 | 1 | 2 | 3 | 4 | 3 | 3 | 3 | 1 | 1 | 1 | 3 |
| 1924 | 4 | 2 | 2 | 2 | 1 | 1 | 4 | 2 | 3 | 3 | 4 | 4 | 4 |
| 1925 | 3 | 1 | 4 | 3 | 1 | 2 | 2 | 2 | 2 | 3 | 1 | 4 | 1 |
| 1926 | 1 | 3 | 4 | 3 | 4 | 2 | 2 | 4 | 3 | 1 | 3 | 3 | 1 |
| 1927 | 1 | 4 | 1 | 4 | 2 | 3 | 3 | 1 | 1 | 4 | 3 | 4 | 1 |

| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | *Year* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1928 | 3 | 3 | 4 | 3 | 2 | 2 | 3 | 3 | 1 | 4 | 1 | 4 | 3 |
| 1929 | 2 | 4 | 4 | 2 | 1 | 4 | 3 | 3 | 3 | 1 | 1 | 3 | 4 |
| 1930 | 3 | 1 | 1 | 1 | 4 | 3 | 3 | 2 | 1 | 1 | 3 | 1 | 1 |
| 1931 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 4 | 4 | 4 | 4 |
| 1932 | 4 | 4 | 2 | 4 | 1 | 4 | 3 | 3 | 3 | 1 | 4 | 4 | 4 |
| 1933 | 4 | 3 | 1 | 4 | 2 | 2 | 3 | 1 | 4 | 1 | 1 | 2 | 2 |
| 1934 | 4 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 1 | 3 | 1 | 3 | 3 |
| 1935 | 4 | 2 | 4 | 2 | 4 | 3 | 3 | 1 | 3 | 3 | 3 | 1 | 3 |
| 1936 | 1 | 1 | 3 | 3 | 1 | 4 | 1 | 4 | 2 | 2 | 4 | 3 | 1 |
| 1937 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 2 | 1 | 3 | 1 | 1 | 1 |
| 1938 | 1 | 3 | 3 | 4 | 2 | 3 | 1 | 1 | 4 | 3 | 3 | 2 | 3 |
| 1939 | 3 | 3 | 2 | 3 | 2 | 1 | 3 | 1 | 2 | 2 | 1 | 4 | 1 |
| 1940 | 2 | 2 | 4 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 4 | 2 |
| 1941 | 2 | 1 | 1 | 2 | 4 | 4 | 2 | 2 | 4 | 2 | 2 | 3 | 2 |
| 1942 | 2 | 2 | 4 | 2 | 1 | 3 | 4 | 3 | 3 | 3 | 4 | 3 | 4 |
| 1943 | 4 | 1 | 3 | 3 | 4 | 2 | 1 | 3 | 3 | 3 | 2 | 2 | 3 |
| 1944 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | 1 | 1 | 4 | 1 |
| 1945 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 4 | 1 | 3 | 3 |
| 1946 | 4 | 1 | 3 | 3 | 1 | 1 | 3 | 3 | 3 | 3 | 1 | 2 | 3 |
| 1947 | 2 | 2 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 1 | 3 |
| 1948 | 1 | 1 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 3 |
| 1949 | 3 | 3 | 4 | 3 | 1 | 4 | 2 | 2 | 3 | 3 | 1 | 3 | 3 |
| 1950 | 2 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 1 | 3 | 1 | 1 | 3 |
| 1951 | 3 | 1 | 1 | 3 | 1 | 1 | 1 | 3 | 1 | 4 | 3 | 3 | 1 |
| 1952 | 1 | 1 | 2 | 3 | 4 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 1 |
| 1953 | 1 | 3 | 3 | 1 | 2 | 1 | 1 | 4 | 3 | 3 | 4 | 4 | 3 |
| 1954 | 2 | 4 | 1 | 2 | 2 | 1 | 2 | 3 | 3 | 4 | 4 | 1 | 2 |
| 1955 | 1 | 1 | 4 | 4 | 4 | 4 | 2 | 2 | 3 | 2 | 3 | 1 | 2 |
| 1956 | 3 | 2 | 4 | 4 | 2 | 2 | 3 | 3 | 3 | 4 | 2 | 4 | 4 |
| 1957 | 4 | 1 | 3 | 3 | 2 | 3 | 1 | 4 | 4 | 4 | 3 | 3 | 3 |
| 1958 | 1 | 1 | 2 | 4 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 1 | 3 |
| 1959 | 1 | 4 | 3 | 1 | 3 | 2 | 1 | 4 | 4 | 4 | 3 | 1 | 3 |
| 1960 | 2 | 2 | 3 | 3 | 4 | 3 | 2 | 4 | 2 | 1 | 1 | 1 | 1 |
| 1961 | 4 | 3 | 3 | 1 | 4 | 3 | 4 | 4 | 3 | 3 | 1 | 4 | 3 |
| 1962 | 3 | 4 | 2 | 3 | 4 | 4 | 2 | 3 | 4 | 3 | 1 | 4 | 4 |
| 1963 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 4 | 3 | 2 | 4 |
| 1964 | 4 | 4 | 2 | 3 | 4 | 1 | 4 | 4 | 2 | 2 | 3 | 2 | 2 |
| 1965 | 1 | 4 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 4 | 2 | 1 | 2 |
| 1966 | 2 | 1 | 3 | 1 | 4 | 2 | 2 | 2 | 4 | 3 | 2 | 1 | 1 |
| 1967 | 2 | 3 | 3 | 2 | 1 | 4 | 3 | 3 | 1 | 3 | 3 | 4 | 3 |
| 1968 | 4 | 3 | 3 | 3 | 3 | 3 | 4 | 2 | 2 | 3 | 1 | 4 | 3 |
| 1969 | 4 | 2 | 4 | 4 | 3 | 2 | 4 | 2 | 3 | 3 | 1 | 1 | 2 |
| 1970 | 2 | 2 | 2 | 2 | 4 | 2 | 2 | 2 | 4 | 4 | 3 | 1 | 2 |
| 1971 | 1 | 3 | 4 | 3 | 3 | 4 | 4 | 3 | 4 | 4 | 2 | 3 | 3 |
| 1972 | 3 | 3 | 3 | 1 | 2 | 3 | 1 | 2 | 4 | 4 | 1 | 3 | 1 |
| 1973 | 3 | 3 | 3 | 2 | 3 | 2 | 4 | 3 | 3 | 4 | 4 | 4 | 4 |
| 1974 | 1 | 1 | 3 | 4 | 2 | 2 | 4 | 1 | 4 | 2 | 3 | 3 | 1 |
| 1975 | 3 | 3 | 1 | 4 | 1 | 2 | 2 | 2 | 3 | 4 | 4 | 3 | 3 |
| 1976 | 1 | 4 | 4 | 3 | 4 | 4 | 3 | 4 | 2 | 3 | 3 | 1 | 4 |
| 1977 | 1 | 1 | 1 | 4 | 3 | 3 | 4 | 4 | 4 | 3 | 1 | 4 | 3 |
| 1978 | 3 | 4 | 3 | 4 | 2 | 2 | 2 | 4 | 4 | 4 | 4 | 1 | 4 |
| 1979 | 2 | 1 | 1 | 4 | 3 | 1 | 4 | 4 | 4 | 4 | 1 | 1 | 3 |
| 1980 | 4 | 3 | 4 | 2 | 4 | 2 | 2 | 4 | 4 | 2 | 2 | 4 | 2 |

events belonging to two time arrays four categories were established for different events: wet-warm (1), wet-cold (2), dry-warm (3) and dry-cold (4) *(Table 3).*

The monthly, yearly (110—110 basic periods) number of repetitions and frequency values of the individual anomaly categories were determined where observations were considered in a continous process starting with the first observation

(1320 basic periods). One repetition means an uninterrupted series of a given weather type occurring during successive basic periods (a month or a year). The number of repetitions and frequency of the individual categories do not contain the first and last repetition of a given basic period, the duration of their series being unknown.

Data thus obtained was considered from two main angles. It was examined if empiric frequency distribution of the repetition of the individual anomaly categories correspond to certain theoretic assumptions, as well as the monthly average durations of repetitions were determined and statistically evaluated.

Our test results emerging from mentioned observation material are as follows: According to basic probabilities of individual anomaly categories *(Table 4)* the recurrence of the warm-dry, (3), anomaly category is the most probable not only during five months (March, April, August, September, October) but considering the yearly time-series and the 1320 months between 1871 and 1980 as well. The wet-cold (2) anomaly category is most common in May, June, July.

Correlating territorial average values of monthly precipitations and mean temperatures for the months of the summer half year (April, May, July, August, September) a statistically realistic contrasting connection can be observed. This is an unambigous consequence of the preponderance of the wet-cold (2) and dry-warm (3) anomaly categories. In the winter half year this connection becomes blurred.

The probability of any anomaly category repeating itself during the month following a given basic period shows a characteristic yearly course. Its value appears to be the highest from January to February, this is mainly a consequence of the greater frequency of wet-warm anomaly category (1), and from February to March as well as from July to August, in latter cases it is mainly a product of the frequent repetition of dry-warm (3) anomaly category. For the months of the intermediate seasons this repetition occurs with a lesser frequency so its probability is lower, too.

Analysing monthly empiric frequency values of the individual anomaly categories an increase can be observed in the repetition periods of wet-cold (2) and dry-warm (3) categories, first of all during the summer half year. To decide if this is a systematic occurence or only a random succession of events, the frequency distribution of repetition periods obtained from independent events was determined *(Table 5)*. In the next step we considered the possibility with the help of $\chi^2$-proof if these two distributions could be regarded as a distribution of specimens taken from a basic agglomeration with identical distribution. According to obtained results the probability of fullfilling hypothesis zero is always at least 10% with the exception of one which means that the specimens origin from a basic agglomeration of identical distribution. Occasionally even better than 90% approaches were obtained. Only calculations referring to the specimen consisting of 1320 months (from 1871 to 1980 regarded as a whole) gave a little higher result than 2% for the fullfillment of hypothesis zero. It can be stated that the empiric frequency distribution of the duration of repetitions — with above mentioned exceptions — is not inconsistent with the independency hypothesis.

After this frequency distribution of repetition periods was determined satisfying the conditions of homogenous Markov-chains *(Table 3)*. As a result of $\chi^2$-proof it was obtained that the previously supposed and the real empiric frequency distribution of repetitive periods can be regarded as specimens originating from a basic agglomeration of identical distribution with a great probability. Considering that on most occasions the independence hypothesis gave closer relation than the conditions of homogenous Markov-chains, the empiric frequency distribution of repetitive pe-

*Table 4*

The $p_i$ basic probabilities of the single $i$ anomaly category, ($i = 1, 2, 3, 4$), 1871—1980

| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | *Year* | *all the months* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $p_1$ | 0,269 | 0,306 | 0,224 | 0,120 | 0,130 | 0,208 | 0,181 | 0,115 | 0,210 | 0,213 | 0,278 | 0,306 | 0,213 | 0,209 |
| $p_2$ | 0,232 | 0,139 | 0,234 | 0,306 | 0,352 | 0,302 | 0,324 | 0,317 | 0,257 | 0,194 | 0,157 | 0,120 | 0,278 | 0,248 |
| $p_3$ | 0,232 | 0,296 | 0,336 | 0,352 | 0,343 | 0,264 | 0,395 | 0,356 | 0,333 | 0,278 | 0,269 | 0,306 | 0,304 | 0,304 |
| $p_4$ | 0,269 | 0,259 | 0,206 | 0,222 | 0,176 | 0,226 | 0,200 | 0,212 | 0,200 | 0,259 | 0,287 | 0,306 | 0,204 | 0,240 |

*Table 5*

*Frequency distribution of recurrences of i weather type (i = 1, 2, 3, 4) in case of independence (a), in real case (b) and in case of homogeneous Markov-chains (c), month*

*January*

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1a: | 16 | 4 | 1 | — |
| 1b: | 17 | 6 | — | — |
| 1c: | 18 | 4 | 1 | — |
| 2a: | 15 | 3 | 1 | — |
| 2b: | 15 | 2 | 2 | — |
| 2c: | 14 | 3 | 1 | — |
| 3a: | 15 | 3 | 1 | — |
| 3b: | 23 | 1 | — | — |
| 3c: | 23 | 1 | — | — |
| 4a: | 16 | 4 | 1 | — |
| 4b: | 13 | 3 | 2 | 1 |
| 4c: | 12 | 4 | 1 | 1 |

*February*

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1a: | 16 | 5 | 1 | — |
| 1b: | 23 | 5 | — | — |
| 1c: | 24 | 4 | 1 | — |
| 2a: | 11 | 2 | — | — |
| 2b: | 11 | 2 | — | — |
| 2c: | 11 | 2 | — | — |
| 3a: | 16 | 5 | 1 | — |
| 3b: | 13 | 3 | 3 | 1 |
| 3c: | 13 | 5 | 2 | 1 |
| 4a: | 15 | 4 | 1 | — |
| 4b: | 16 | 6 | — | — |
| 4c: | 17 | 4 | 1 | — |

*March*

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1a: | 14 | 3 | 1 | — |
| 1b: | 20 | 2 | — | — |
| 1c: | 20 | 2 | — | — |
| 2a: | 15 | 3 | 1 | — |
| 2b: | 14 | 4 | 1 | — |
| 2c: | 14 | 3 | 1 | — |
| 3a: | 16 | 5 | 2 | 1 |
| 3b: | 19 | 4 | 3 | — |
| 3c: | 19 | 5 | 1 | — |
| 4a: | 14 | 3 | 1 | — |
| 4b: | 12 | 5 | — | — |
| 4c: | 13 | 3 | 1 | — |

*April*

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1a: | 10 | 1 | — | — |
| 1b: | 13 | — | — | — |
| 1c: | 13 | — | — | — |
| 2a: | 16 | 5 | 1 | — |
| 2b: | 21 | 3 | 2 | — |
| 2c: | 20 | 4 | 1 | — |

*April*

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 3a: | 16 | 6 | 2 | 1 |
| 3b: | 22 | 3 | 1 | — |
| 3c: | 19 | 6 | 2 | — |
| 4a: | 15 | 3 | 1 | — |
| 4b: | 15 | 3 | 1 | — |
| 4c: | 15 | 3 | 1 | — |

3b: recurrence of 7 months on one occasion

*May*

| | | | | |
|---|---|---|---|---|
| 1a: | 11 | 1 | — | — |
| 1b: | 12 | 1 | — | — |
| 1c: | 12 | 1 | — | — |
| 2a: | 16 | 6 | 2 | 1 |
| 2b: | 11 | 6 | 3 | — |
| 2c: | 12 | 5 | 2 | 1 |
| 3a: | 16 | 5 | 2 | 1 |
| 3b: | 16 | 3 | 1 | 3 |
| 3c: | 14 | 5 | 2 | 1 |
| 4a: | 13 | 2 | — | — |
| 4b: | 12 | 2 | 1 | — |
| 4c: | 12 | 2 | 1 | — |

2b: recurrence of 6 months on one occasion

*June*

| | | | | |
|---|---|---|---|---|
| 1a: | 14 | 3 | 1 | — |
| 1b: | 15 | 2 | 1 | — |
| 1c: | 15 | 3 | — | — |
| 2a: | 16 | 5 | 1 | — |
| 2b: | 15 | 7 | 1 | — |
| 2c: | 17 | 5 | 1 | — |
| 3a: | 15 | 4 | 1 | — |
| 3b: | 20 | 4 | 1 | — |
| 3c: | 21 | 3 | — | — |
| 4a: | 14 | 3 | 1 | — |
| 4b: | 22 | 1 | — | — |
| 4c: | 22 | 1 | — | — |

*July*

| | | | | |
|---|---|---|---|---|
| 1a: | 13 | 2 | — | — |
| 1b: | 11 | 2 | — | 1 |
| 1c: | 10 | 3 | 1 | — |
| 2a: | 16 | 5 | 2 | 1 |
| 2b: | 11 | 7 | 3 | — |
| 2c: | 13 | 5 | 2 | 1 |
| 3a: | 15 | 5 | 1 | — |
| 3b: | 15 | 2 | 1 | — |
| 3c: | 12 | 5 | 2 | 1 |
| 4a: | 13 | 3 | 1 | — |
| 4b: | 14 | 2 | 1 | — |
| 4c: | 14 | 3 | — | — |

3b: recurrence of 9 months on one occasion

*August*

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1a: | 9 | 1 | — | — |
| 1b: | 10 | 1 | — | — |
| 1c: | 10 | 1 | — | — |
| 2a: | 15 | 5 | 2 | — |
| 2b: | 14 | 8 | 1 | — |
| 2c: | 16 | 5 | 1 | — |
| 3a: | 15 | 5 | 2 | 1 |
| 3b: | 20 | 2 | 2 | — |
| 3c: | 17 | 5 | 2 | 1 |
| 4a: | 14 | 3 | 1 | — |
| 4b: | 15 | 2 | 1 | — |
| 4c: | 15 | 3 | — | — |

3b: recurrence of 7 months on one occasion

*September*

| | | | | |
|---|---|---|---|---|
| 1a: | 14 | 3 | 1 | — |
| 1b: | 13 | 3 | 1 | — |
| 1c: | 13 | 3 | 1 | — |
| 2a: | 15 | 4 | 1 | — |
| 2b: | 18 | 2 | — | — |
| 2c: | 16 | 4 | 1 | — |
| 3a: | 16 | 5 | 2 | 1 |
| 3b: | 16 | 2 | 1 | 3 |
| 3c: | 14 | 5 | 2 | 1 |
| 4a: | 13 | 3 | 1 | — |
| 4b: | 14 | 2 | 1 | — |
| 4c: | 14 | 3 | — | — |

2b: recurrence of 5 months on one occasion

*October*

| | | | | |
|---|---|---|---|---|
| 1a: | 14 | 3 | 1 | — |
| 1b: | 15 | 4 | — | — |
| 1c: | 16 | 3 | — | — |
| 2a: | 14 | 3 | 1 | — |
| 2b: | 16 | 1 | 1 | — |
| 2c: | 15 | 2 | — | — |
| 3a: | 16 | 5 | 2 | 1 |
| 3b: | 13 | 8 | 1 | 1 |
| 3c: | 15 | 5 | 2 | 1 |
| 4a: | 15 | 4 | 1 | — |
| 4b: | 16 | 4 | — | 1 |
| 4c: | 16 | 4 | 1 | — |

*November*

| | | | | |
|---|---|---|---|---|
| 1a: | 16 | 4 | 1 | — |
| 1b: | 16 | 4 | 2 | — |
| 1c: | 16 | 4 | 1 | — |
| 2a: | 12 | 2 | — | — |
| 2b: | 13 | 2 | — | — |
| 2c: | 13 | 2 | — | — |
| 3a: | 16 | 4 | 1 | — |
| 3b: | 17 | 5 | 1 | — |
| 3c: | 18 | 4 | 1 | — |

*November*

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 4a: | 16 | 5 | 1 | — | | |
| 4b: | 20 | 4 | 1 | — | | |
| 4c: | 20 | 4 | 1 | — | | |

*December*

| | | | | |
|---|---|---|---|---|
| 1a: | 16 | 5 | 1 | — |
| 1b: | 16 | 4 | 3 | — |
| 1c: | 16 | 5 | 1 | — |
| 2a: | 10 | 1 | — | — |
| 2b: | 9 | 2 | — | — |
| 2c: | 9 | 1 | — | — |
| 3a: | 16 | 4 | 1 | — |
| 3b: | 15 | 5 | — | 1 |
| 3c: | 15 | 4 | 1 | — |
| 4a: | 16 | 5 | 1 | — |
| 4b: | 18 | 6 | 1 | — |
| 4c: | 19 | 5 | 1 | — |

*Year*

| | | | | | | |
|---|---|---|---|---|---|---|
| 1a: | 14 | 3 | 1 | — | — | — |
| 1b: | 14 | 3 | 1 | — | — | — |
| 1c: | 14 | 3 | 1 | — | — | — |
| 2a: | 16 | 4 | 1 | — | — | — |
| 2b: | 7 | 5 | 3 | 1 | — | — |
| 2c: | 9 | 4 | 2 | 1 | — | — |
| 3a: | 16 | 5 | 1 | — | — | — |
| 3b: | 16 | 4 | 1 | — | — | 1 |
| 3c: | 15 | 5 | 2 | 1 | — | — |
| 4a: | 14 | 3 | 1 | — | — | — |
| 4b: | 11 | 4 | 1 | — | — | — |
| 4c: | 12 | 3 | 1 | — | — | — |

*month* (1871—1980)

| | | | | | | |
|---|---|---|---|---|---|---|
| 1a: | 172 | 36 | 7 | 2 | — | — |
| 1b: | 126 | 42 | 16 | 3 | 1 | — |
| 1c: | 129 | 41 | 13 | 4 | 1 | — |
| 2a: | 185 | 46 | 11 | 3 | 1 | — |
| 2b: | 147 | 49 | 16 | 3 | 2 | 2 |
| 2c: | 147 | 48 | 16 | 5 | 2 | 1 |
| 3a: | 194 | 59 | 18 | 5 | 2 | — |
| 3b: | 153 | 61 | 18 | 9 | 3 | 1 |
| 3c: | 153 | 58 | 22 | 9 | 3 | 1 |
| 4a: | 183 | 44 | 11 | 3 | 1 | — |
| 4b: | 160 | 47 | 10 | 4 | 2 | 1 |
| 4c: | 159 | 46 | 13 | 4 | 1 | — |

3b: recurrence of 7 months on two occasions riods — in according with above mentioned facts — can be regarded as products of independent events.

The relationship between the average actual and independent duration of repetitions was observed, too. According to our calculations there is a minimal probability of the average duration of repetitions being a consequence of independent events considering every anomaly category, that is the months of February, March, April (wet-warm (1) anomaly category), the wet-cold (2) category in yearly sequence as well as a continous process (from 1871 to 1980) consisting of 1320 months. In all of the remaining cases the independency is valid which means that the average duration of repetitions is not contradictory to a random connection of events of the time-sequence (the succession of different types).

During our experiments explanations were found to the following problems: The characteristic climate of Hungary, first of all in summer half-year, is due to monthly basic probabilities of the different weather types; the different monthly frequency of the individual anomaly categories is explained by a correlation of territorial average values of monthly precipitations and mean temperatures and it was understood that the frequency distribution of repetitive periods of the different types can be regarded as products of independent occurences. Similarly, the average duration of repetitions — with the exception of the continously observed time-sequence containing 1320 minths — do not significantly diverge from independent average durations [2].

### References

[1] *Péczely Gy.*: A statistical investigation on the secular precipitation series of Hungary. Acta Clim. Univ. Szegediensis, Tom. XIII., Fasc. 1—4., 1974., p. 3—14.

[2] *Makra, L.*, Egyidejű havonkénti hőmérséklet- és csapadékanomáliák kategóriái és néhány statisztikai jellemzőjük Magyarországon. (Categories of simultaneous monthly temperature and precipitation anomalies and some of their statistical characteristics in Hungary.) Időjárás. *87*. 4. Budapest, 1983. p. 214—220.