

NON-PERIODICAL VARIATIONS OF PRECIPITATION QUANTITIES AND THEIR NEGATIVE DEVIATION ON THE TERRITORY OF MOLDOVA

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Abstract. The content of this article reflects the variation of rainfall quantities that are not periodical and their negative deviation on the Republic of Moldova territory. The informational base was offered by the Hydrometeorological Service of State, and the final conclusion says that drought in Moldova is not a fortuitous phenomenon of nature, but constitutes a law.

Introduction

In Moldova, phenomena of drought and dryness which are directly connected with the precipitation regime and temperature registered great periodic variations [2, 3, 4].

In order to determine how great the proportions of some droughts were, it was necessary to calculate the negative deviations of the annual and monthly quantities in comparison with the multiannual average quantities, which are considered normal during the warm semester of the year.

1. Negative deviation of the average precipitation quantities during the warm semester of the year

The soil provision with productive water is ensured by the precipitations during the cold semester of the year (X-III) as well as those during the warm semester (IV-IX), when the vegetation is in full process of development.

The quantities of precipitations during these two semesters are very uniform in time and place, especially in time.

Examining the smallest precipitation quantities of the warm semester of the year, it can be stated that these were recorded in different years as well as the

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average annual ones. There are some exceptions, too: 1951 (Chișinău, Camenca) and 1986 (Bravicea, Ștefan Vodă).

According to Table 1, the smallest precipitation quantities during the warm semester of the year were recorded in Tiraspol – 113 mm (1948), then Comrat – 117 mm (1895), Soroca – 141 mm (1892). During these years, the vegetation suffered greatly.

Tab. 1 - The smallest quantities of precipitations during the warm semester of the year (IV-IX) and their deviation in Moldova

Station	Quantity	Year	Deviation (mm)	Multiannual average data
1. Briceni	204	1952	-193	397
2. Soroca	141	1892	-199	340
3. Râbrnița	167	1999	-168	335
4. Bălți	139	1939	-195	334
5. Camenca	216	1951	-130	346
6. Fălești	200	1963	-169	369
7. Cornești	144	1946	-247	391
8. Bravicea	20	1986	-171	378
9. Bălțata	159	1973	-164	323
10. Chișinău	158	1951	-160	318
11. Leova	156	1973	-169	325
12. Tiraspol	113	1948	-189	302
13. Ștefan-Vodă	161	1986	-156	317
14. Ceadâr-Lunga	185	1996	-124	309
15. Comrat	117	1895	-178	295
16. Dubăsari	143	1895	-168	311
17. Cahul	165	1923	-157	322

The greatest negative deviations of precipitation quantities during the warm semester were recorded during the years when the precipitation quantities were the smallest and they varied between 200-247 mm in the central and northern parts, showing a decreasing tendency from north to south and even from west to east: Soroca – 199 mm, Cornești – 247 mm, Ceadâr-Lunga – 124 mm, Cahul – 157 mm.

It can be observed that the greatest deviations occur where precipitation quantities during the warm semester are bigger in the north and center (but the drought has less effect on the vegetation). On the other hand, the smallest deviations occur where the precipitation quantities during the warm semester of the year are smaller (but the drought is more prominent) i.e. in the south-east of Moldova, where continental arid influence is greater.

2. The frequency of pluvially deficient periods (during consecutive warm semesters)

During the years the warm semesters are characterized by summer droughts which occur consecutively (tab. 2).

Tab. 2 - The frequency of deficient pluviometric periods durations of different (during consecutive warm semesters) in Moldova

Station	Periods					Total periods	Total warm semesters
	2	3	4	5	>5		
1. Briceni	4	2	1	–	1 (6 sem.)	8	24
2. Soroca	6	1	1	1	1 (6 sem.)	10	30
3. Râbnîța	3	1	–	–	1 (6 sem.)	5	15
4. Bălți	5	1	–	1	–	7	18
5. Camenca	3	1	1	–	–	5	13
6. Fălești	4	–	–	–	1 (10 sem.)	5	18
7. Cornești	6	–	1	1	–	8	21
8. Bravicea	3	2	–	1	–	6	17
9. Bălțata	4	1	–	1	–	6	16
10. Chișinău	8	5	–	1	–	14	34
11. Leova	6	2	1	–	–	9	22
12. Tiraspol	6	4	–	–	–	10	24
13. Ștefan-Vodă	3	1	–	–	–	4	9
14. Ceadâr-Lunga	4	–	1	1	–	6	17
15. Comrat	6	–	–	2	–	8	22
16. Dubăsari	5	2	–	2	–	9	26
17. Cahul	6	1	–	1	–	8	20

We can see that all stations have registered a prevalence of short pluvially deficient periods of 2-3 consecutive warm semesters; most of them are registered in Chișinău (a longer period of observations), then in the west of the republic (Leova - 6), and more reduced in the east (Ștefan Vodă – 3, Râbnîța - 3).

The number of pluvially deficient periods decreases concomitantly with the increase of their duration. Thus, the greatest number of periods longer than 5 consecutive warm pluvially deficient semesters, was only once registered in Briceni, Soroca, Râbnîța, Fălești. The longest successive pluvially deficient period during the warm semesters was of 10 years: 1958-1967 (tab. 3).

Tab. 3 - Succession of deficient pluviometric periods of different durations (during consecutive warm semesters) in Moldova (1)

Station / Period	2 sem.	3 sem.	4 sem.	5 sem.	>5 sem.
1. Briceni	1938-1939 1963-1964 1966-1967 1999-2000	1982-1984 1992-1994	1950-1953	–	1956-1961 (6 semesters)
2. Soroca	1908-1909 1938-1939 1966-1967 1982-1987 1999-2000	1989-1900	1928-1931	1950-1954	1891-1896 (6 semesters)
3. Râbnița	1975-1976 1986-1987 1999-2000	1965-1967	–	–	1956-1961 (6 semesters)
4. Bălți	1915-1916 1942-1943 1959-1960 1962-1963 1999-2000	1965-1967	–	1950-1954	–
5. Camenca	1939-1980 1962-1963 1999-2000	1965-1967	1951-1954	–	–
6. Fălești	1976-1977 1982-1983 1986-1987 1999-2000	–	–	–	1958-1967 (10 sem.)
7. Comești	1946-1947 1962-1963 1966-1967 1982-1983 1986-1987 1999-2000	–	1951-1954	1956-1960	–
8. Bravicea	1953-1954 1956-1957 1967-1968	1981-1983 1998-2000	–	1959-1963	–
9. Bălțata	1956-1957 1973-1974 1986-1987 1999-2000	1959-1961	–	1963-1967	–

We can notice that the highest number of deficient periods of different durations (>2 warm consecutive semesters) were registered in the capital of the republic (Chișinău – 14), followed by Soroca (10), Tiraspol (10), Leova (9), Dubăsari (9), etc.

But, totalizing the consecutive warm pluviometric deficient periods, we can state that most of them occurred in Chișinău (34 warm semesters), followed by Soroca (30), Dubăsari (26), Briceni (24).

In conclusion, we observe the following tendency: the reduction of the frequency of warm consecutive pluviometric deficient periods from N to S and from W to E concomitantly with the drought intensity increase.

Tab. 3 - Succession of deficient pluviometric periods of different durations (during consecutive warm semesters) in Moldova (2)

Station / Period	2 sem.	3 sem.	4 sem.	5 sem.	≥5 sem.
1. Chişinău	1908-1909 1923-1924 1934-1935 1938-1939 1950-1951 1956-1957 1981-1982 1999-2000	1894-1896 1900-1902 1916-1921 1928-1930 1967-1969	-	1959-1962	-
2. Leova	1962-1963 1982-1983 1986-1987 1989-1990 1994-1995 1998-1999	1928-1930 1965-1967	1951-1954	-	-
3. Tiraspol	1924-1925 1934-1935 1945-1946 1950-1951 1969-1940 1981-1982	1928-1930 1965-1967 1973-1975 1985-1987	-	-	-
4. Ştefan-Vodă	1967-1968 1973-1974 1992-1993	1981-19830	-	-	-
5. Ceadăr-Lunga	1956-1957 1973-1974 1986-1987 1995-1996	-	1981-1984	1959-1963	-
6. Comrat	1899-1900 1950-1951 1976-1977 1981-1982 1986-1987 1999-2000	-	-	1925-1929 1992-1996	-
7. Dubăsari	1895-1896 1938-1939 1956-1957 1973-1974 1986-1987	1928-1930 1965-1967	-	1950-1954 1959-1963	-
8. Cahul	1922-1923 1927-1928 1934-1935 1962-1963 1981-1982 1994-1995	1986-1988	-	1950-1954	-

3. The frequency of single warm pluvially deficient semesters

The periods of consecutive warm pluvially deficient semesters are interspersed with pluvially exceeding periods or relatively normal periods (more than 50 mm) and they occur as single isolated phenomena. Their number is greater in the west, north and centre (Soroca – 23 isolated warm semesters, Chişinău – 26, etc). But, if we compare the isolated warm pluvially deficient semesters with more

then 50 mm and the isolated pluviually deficient years with more than 100 mm, it can be noticed that very few of these warm semesters coincide with the respective years. For example, such a coincidence was observed in Briceni in 1945, 1946, 1953, 1982, 2000; in Chișinău – 1896, 1902, 1908, 1921, 1924, 1929, 1938, 1945, 1951, 1953, 1957, 1973, 1982. This coincidence shows the marked droughty character of these years, and that the deficit is determined by the reduced precipitation quantity during the cold semester of the year and partially during the warm semester.

Tab. 4. Isolated pluviually deficient semesters with negative deviations >50 mm (1)

Briceni	Year (mm)	1938 -78	1945 -57	1946 -185	1947 -88	1950 -106	1952 -193	1953 -143	1956 -121	1961 -60	1963 -103	1966 -61			
		0	1967 -114	1982 -72	1983 -56	1984 -54	1992 -54	1994 -54	1999 -90	2000 -94					
Soroca	Year (mm)	1891 -61	1891 -199	1894 -66	1895 -61	1896 -99	1899 -51	1900 -167	1909 -167	1928 -79	1929 -55	1935 -61	1939 -149		
		1946 -105	1947 -105	1950 -52	1951 -80	1952 -111	1953 -156	1954 -64	1966 -92	1967 -103	1986 -134	1999 -145			
Râbnita	Year (mm)	1928 -141	1957 -90	1959 -122	1960 -99	1965 -95	1966 -81	1967 -99	1986 -119	1987 -67	1999 -168	2000 -52			
Bălți	Year (mm)	1915 -97	1916 -119	1939 -195	1942 -57	1943 -64	1952 -75	1953 -172	1954 -75	1959 -76	1960 -102	1963 -61	1965 -85		
							1966 -125	1967 -121	1999 -73						
Camenca	Year (mm)	1951 -130	1952 -73	1953 -102	1954 -58	1959 -88	1960 -114	1963 -73	1965 -97	1966 -85	1999 -58	2000 -58			
Fălești	Year (mm)	1958 -104	1959 -140	1960 -102	1961 -52	1963 -169	1965 -81	1966 -92	1982 -84	1986 -116	1987 -80	2000 -70			
Cornești	Year (mm)	1946 -247	1947 -75	1951 -92	1952 -102	1953 -230	1954 -98	1957 -64	1960 -65	1966 -93	1967 -153	1982 -71	1986 -193	1987 -52	2000 -70
Braveica	Year (mm)	1953 -120	1954 -57	1956 -92	1957 -104	1959 -109	1960 -134	1961 -83	1962 -58	1963 -62	1967 -88	1968 -67	1983 -90	1999 -63	2000 -126
Băltața	Year (mm)	1957 -110	1961 -82	1966 -85	1967 -93	1973 -164	1986 -139	1999 -64	2000 -128						
Chișinău	Year (mm)	1895 -144	1896 -139	1900 -87	1902 -143	1908 -98	1909 -69	1916 -102	1917 -88	1921 -64	1923 -131	1924 -78	1928 -151	1929 -111	1935 -97
		1938 -160	1939 -155	1945 -108	1946 -108	1951 -160	1953 -100	1957 -63	1967 -61	1981 -104	1982 -83	1999 -119	2000 -88		

4. Pluviually deficient years and months

Pluviually deficient years. The decrease of average annual precipitation quantities by 15-20% (and monthly quantities – by 30-50%) in comparison with average multiannual quantities determines them (by Hellman) as very or excessively droughty. In our republic, such years are very frequent and the most

significant are: 1896, 1902, 1928, 1945, 1946, 1948, 1953, 1957, 1967, 1973, 1982, 1986, 1990, 1994, 2000 etc. 1945 and 1946 are characterized by the most violent droughts of the century accompanied by the most disastrous consequences for Moldova and represent a special subject in the case study.

Tab. 4 - Isolated pluviually deficient semesters with negative deviations >50 mm (2)

Leova	Year (mm)	1930	1951	1952	1953	1962	1963	1967	1982	1986	1990	1992	1994	1995		
		-64	-102	-119	-96	-112	-58	-84	-61	-107	-109	-107	-102	-102		
Tiraspol	Year (mm)	1924	1928	1929	1935	1939	1945	1946	1953	1960	1961	1963	1965	1966	1968	
		-127	-119	-84	-153	-62	-159	-189	-123	-69	-64	-57	-60	-86	-144	
						1973	1981	1986	1990	1992						
						-82	-67	-110	-70	-125						
Ștefan-Vodă	Year (mm)				1967	1973	1982	1983	1992	1933	1990					
					-140	-132	-73	-84	-126	-84	-118					
Ceadăr-Lunga	Year (mm)			1960	1962	1963	1986	1987	1990	1992	1995	1996				
				-112	-70	-57	-87	-75	-93	-122	-69	-124				
Comrat	Year (mm)	1900	1902	1921	1922	1925	1928	1929	1951	1953	1965	1967	1973	1982	1986	1987
		-69	-70	-62	-65	-111	-178	-149	-68	-121	-52	-125	-77	-93	-107	-136
								1990	1992	2000						
								-99	-151	-97						
Dubăsari	Year (mm)	1895	1896	1928	1938	1939	1951	1952	1953	1957	1939	1960	1961	1962	1967	1969
		-168	-73	-153	-100	-128	-77	-76	-89	-111	-99	-58	-93	-73	-61	-56
								1973	1990	1999						
								-100	-106	-85						
Cahul	Year (mm)	1922	1923	1925	1927	1928	1935	1950	1951	-1952	1954	1956	1960	1965	1967	
		-69	-157	-134	-77	-111	-137	-55	-61	-99	-90	-52	-62	-91	-74	
		1990	1992	1995	2000											
		-146	-138	-71	-155											

In general, during the droughty years, the quantities of precipitations are much smaller than average multiannual ones.

For example, in Cornești, in 1896, the quantity of precipitations was of only 358 mm, e.i. 43,6% less than average multiannual quantity; in Soroca, the quantity was of 293 mm, e.i. 45% less than the average multiannual quantity; in Comrat in 1928, - 222 mm, the deficit was of 54,3%.

Table 5 shows some of the most prominent precipitation quantity deviations from the average multiannual data during the droughtiest years of the century.

Some detailed analyses of particular situations during very deficient years have been made.

In 1953, an intensive anticyclone activity led to an essential decrease of the precipitation quantity. That year was qualified as an excessively droughty one (by Hellman criterion) - ($P < - 20\%$). 7 out of 12 months were pluviually deficient (March, June, July, August, September, October, November). The most affected

districts were in the south of the country: Dubăsari – 392 mm, Comrat – 335 mm, Tiraspol – 295 mm. In 1928, the drought affected probably the whole country territory, but data are only available for a few regions: Chișinău, Dubăsari, Comrat, Soroca, Tiraspol, Râbnița, Leova. The annual precipitation quantity characterized the year as pluvially normal, but the sums of warm semester months confirm that it had a droughty character.

Tab. 5 - Annual precipitation deficit during the droughtiest years

Nr.	Station	Year	Deviation (%)
1.	Briceni	1982,1983	30,3
2.	Soroca	1953	45,0
3.	Bălți	1994	33,8
4.	Camenca	1951	35,7
5.	Fălești	1963	34,4
6.	Cornești	1986	43,6
7.	Râbnița	1982	37,9
8.	Bravicea	1986	40,1
9.	Bălțata	1973	35,3
10.	Chișinău	1896	43,0
11.	Leova	1973	40,0
12.	Tiraspol	1924	44,7
13.	Ștefan Vodă	1983	42,4
14.	Ceadâr-Lunga	1983	39,7
15.	Dubăsari	1961	32,2
16.	Cahul	1925	42,5

Pluvially deficient months. During the year, the greatest precipitation deficit is observed especially in spring (March, April), autumn (September) and summer (July, August). In the last centuries, the most droughty March months were recorded in 1921, 1929, 1953, 1983; the most droughty September months – in 1945, 1950, 1961, 1986, 1994. According to the Hellmann criterion, they are classified as excessively droughty months ($P > - 50\%$).

In March 1929, the precipitation deficit exceeded 50%. The precipitation quantity did not exceed 6-9 mm (Cahul – 6, Dubăsari – 2, Soroca – 2, Leova – 3, Cahul - 2). The great precipitation deficit was caused by the long duration of the Atlantic Ocean anticyclone that contributed to the warm and dry air masses advection. At some stations, the highest temperatures exceeded 20°C: Briceni – 21,3°C, Chișinău – 21,9°C, Comrat – 21,3°C, Cahul – 20,7°C, Tirapol – 22,3°C. The precipitation deficit reached 25-30 mm.

In September 1986, drought was caused by the fusion of the Azores and East-European anticyclones which led to the advection of warm and dry continental air masses. The highest temperatures exceeded 30°C (Chişinău – 32,8°C, Comrat – 33,5°C, Briceni – 32°C, Cahul - 32,1°C, Bravicea – 34,0°C, Bălţata – 32,7°C, Corneşti – 32,9 C, Bălţi – 33,5°C, Tiraspol – 34,4°C). The precipitation deficit averaged 35-39 mm.

In **conclusion**, it can be stated that drought in Moldova is not an accidentally occurring natural phenomenon, but a regularity and its manifestation has a permanent character. This should be taken into consideration in the attempt to outrun its destructive power.

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