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THE FREQUENCY OF NORMAL AND ABNORMAL SUMS OF ATMOSPHERIC FALLS IN LĘBORK IN 1861-2000

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Abstract

The authors of the present paper made an attempt to determine frequency of average, dry and wet periods for months, seasons, half-years and years. Additionally a comparison of data recorded during 140 years allows to check the structure of excessively wet and excessively dry years' patterns. The present paper is based on the Z. Kaczorowska's classification (1962).

Key words: periods – average, extremely dry, extremely wet, Lębork

INTRODUCTION

After analyzing the many years precipitation's sums, M. Kirschenstein (2008b) found out that an annual course of precipitation's sums is frequently characterized by the oceanic features than the continental ones and it is a result of the Baltic Sea influence and the Atlantic Ocean manifesting itself by more intensive precipitation in the cold half-year. Moreover, M. Kirschenstein (2008a) discovered that the precipitation's maximum often occurs not only in July, but also in August, September and October whereas low sums recorded in February, March and April confirm a strong influence of the Baltic Sea. The Baltic Sea cools down and influences the decrease of precipitation's sums in spring and early summer. However increasing of contrasts at the border of the sea and land recorded from July to November has a significant impact on the growth of precipitation's sums, that is why autumn is characterized by high falls' sums. The author also defined the trends of precipitation changes during a many-years' period and discovered that the trend of a precipitation's sums increase occurred in all months, seasons and half-years. Since precipitation's sums recorded in Lębork are characterized by high time changeability, she made an attempt to determine how often average, dry and wet periods occurred in the analyzed area. The analysis was based on the Z. Kaczorowska's classification (1962). The author adopted the following criteria for the monthly, seasonal, half-year and annual precipitation:

1. Extremely dry – a precipitation's sum below 50% of an average standard of a many-years' sum (deficiency of precipitation above 50%),
2. Very dry – a precipitation's sum is 50-74% of a standard (deficiency of precipitation is 26%),
3. Dry – a precipitation's sum is 75-89% of a standard (deficiency of precipitation is 11%),
4. Average – a precipitation's sum ranges between 90-110% of a standard (departure from the average many years' sum does not exceed 50%),
5. Wet – a precipitation's sum is 111-125% of a standard (excess of precipitation is 11%),
6. Very wet – a precipitation's sum is 126-150% of a standard (excess of precipitation is 26%),
7. Extremely wet – a precipitation's sum is above 150% of a standard (excess of precipitation is 50%).

Annual precipitation coefficients are calculated on the basis of average monthly precipitation sums registered between 1861-2000. The data come from the various sources. The data registered before the Second World War come from the Atlas of atmospheric precipitation frequency in Poland (1961) and from Works and Studies KGW (1959). The data registered after the Second World War come from the annuals and archives of IMGW. All missing information the author supplemented by using the quotient method based on data provided by various observation centers. In order to verify the hypothesis of homogeneity of processes precipitation series the author used non-parametric Smirnov-Kolmogorov test. The author also checked accordance of constant precipitation series registered between 1861 and 1949, and 1950 and 2000. The result of the test $\lambda = 0.95$ is lower than the critical value of statistics on the significance level 0.5 ($\lambda_{0.05} = 1.36$). If $\lambda < \lambda_{0.05}$ we can assume the series is probably homogenous.

FREQUENCY OF AVERAGE, DRY AND WET PERIODS

The present analysis includes the criteria presented in the Z. Kaczorowska's classification (1962). The classification was generalized in order to compare the frequency of years characterized by sums below or above many-years' average. The authors defined three criteria: average periods (a precipitation's sum ranges between 90-110% of a standard), extremely dry periods (a precipitation's sum $\leq 89\%$ of an average many-years' sum standard) and extremely wet periods (a precipitation's sum $\geq 111\%$ of an average many-years' sum standard).

THE MONTHS

The months with a deficiency of precipitation occurred more often than the months with an excess of precipitation in the whole many-years' period. The frequency of average months decreased (in comparison to seasons, half-years and year), whereas

the frequency of extremely wet (the frequency ranged from 10.7% in September to 19.3% in May) and extremely dry (from 11.4% in April to 25.0% in October) months increased (Fig. 1). In general very dry months occurred more often than the dry ones (except for January and August) and very wet months occurred more often than the wet ones (except for July). The records show that extremely dry months occurred more often than the extremely wet ones (Fig. 2).

The most of the extremely dry months recorded in the analyzed many-years' period occurred in March (50.0%), April (54.2%) and October (52.9%), whereas the extremely wet in June (39.3%), August (38.6%), September (39.3%), November (38.6%) and December (37.9%).

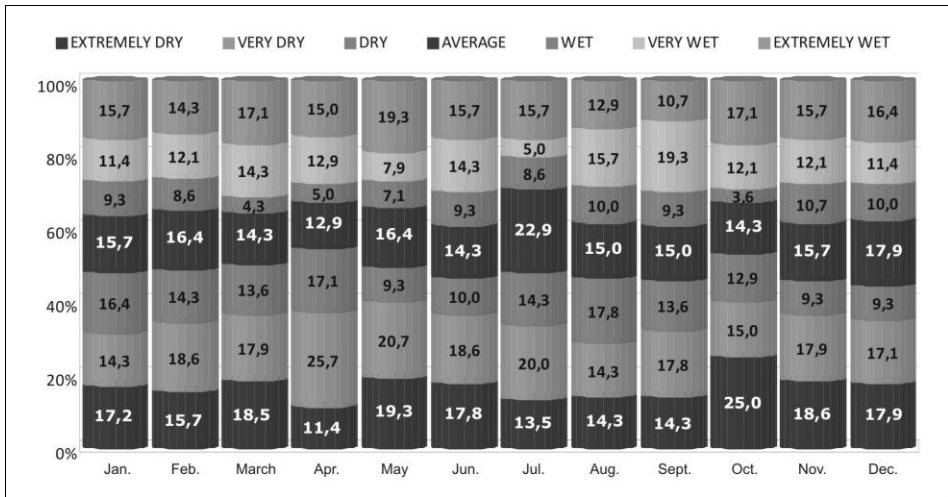


Fig. 1. The frequency of average, dry and wet periods for monthly precipitation's sums (1861-2000)

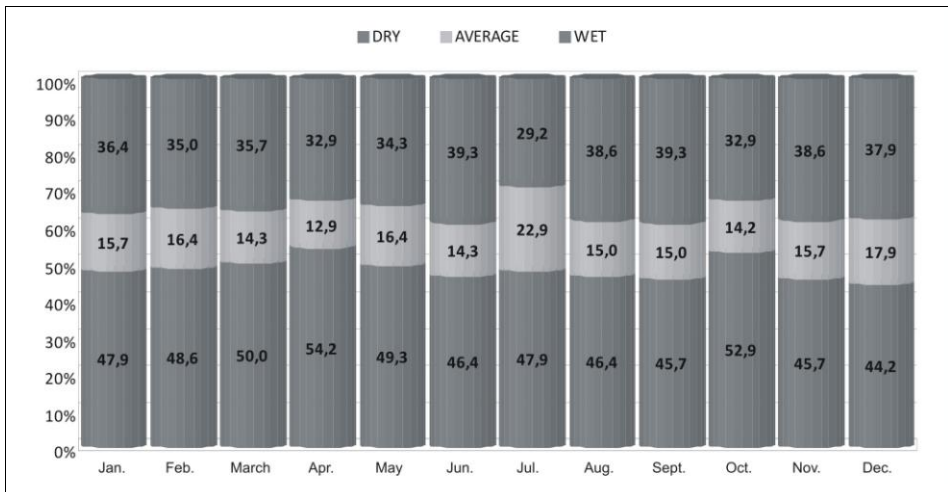


Fig. 2. Periods: average, extremely dry, extremely wet (1861-2000)

During the analyzed many-years' period of years 1861-2000 monthly precipitation's sums were characterized by significant variations in respect of a many-years' average (January: 12-258%, February: 12-290%, March: 11-259%, April: 8-264%, May: 12-259%, June: 0-255%, July: 17-278%, August: 6-242%, September: 12-269%, October: 3-329%, November: 4-274%, December: 8-288%). Every month, might be characterized extremely dry one year and extremely wet the following one.

THE SEASONS

The seasons are characterized by some diversity. The authors analyzed all criteria of the classification. After comparing the seasons that are characterized by a deficiency or excess of precipitation's sums, the authors discovered that springs, summers, autumns and winters with a deficiency of precipitation occur more often (spring – 42.8%, summer – 39.3%, autumn – 41.4%, winter – 37.9%), than those with an excess of precipitation (spring – 33.6%, summer – 32.1%, autumn – 34.3%, winter – 35.7%), (Fig. 4). The results show that most of all average years occurred in summer, excessively dry – in spring and excessively wet – in winter.

The authors analyzed all the categories (Fig. 3) and discovered that:

- The average seasons occurred most often in the whole many-years' period,
- There were more extremely wet than extremely dry seasons,
- The extremely dry seasons occur in a category of very dry and very wet seasons,
- Similar situation occurs while comparing dry and wet seasons, the exception is winter that more often is wet (16.4%) than dry (14.3%),
- There were very considerable differences between extreme precipitation's sums in all seasons (spring: 40-202%, summer: 22-181%, autumn: 32-209%, winter: 20-201%).

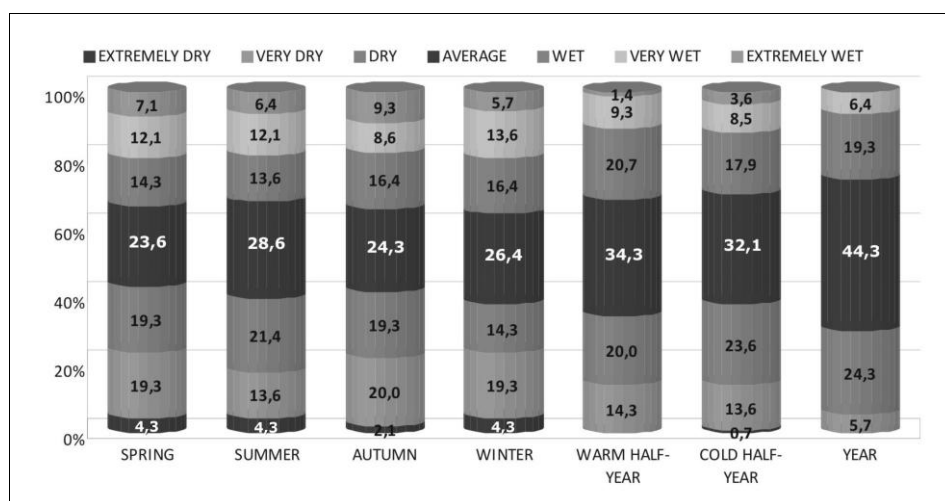


Fig. 3. The frequency of average, dry and wet periods for precipitation's sums: recorded in seasons, half-years and year (1861-2000)

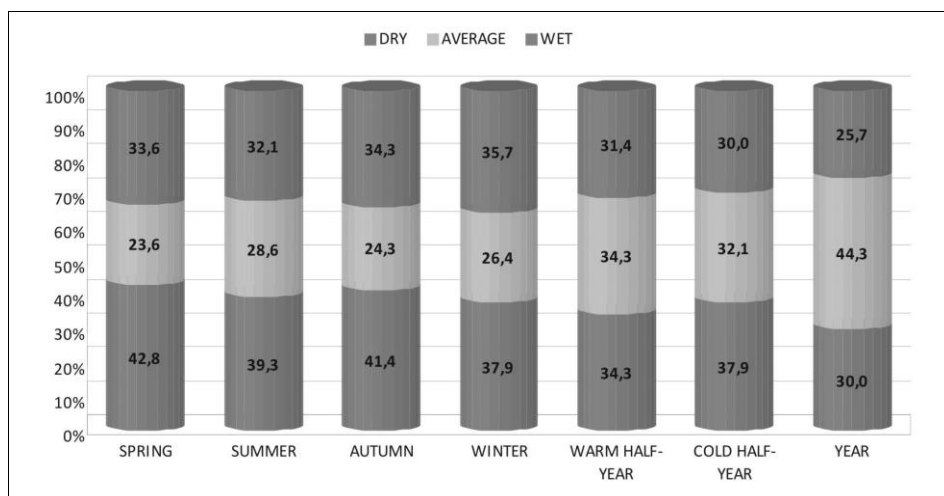


Fig. 4. The frequency of average, extremely dry and extremely wet periods for precipitation's sums: recorded in seasons, half-years and year (1861-2000)

THE WARM HALF-YEAR AND THE COLD

The extremely dry years did not occur in a warm half-year (May-Oct.), however there were the extremely wet years (in 1974 and 1998), whereas very dry and very wet years tend to occur more often (Fig. 3). Dry and wet years occur with similar frequency. Similar patterns can be observed in a cold half-year (Nov.- Apr.). The only difference is that we can observe an occurrence of an extremely dry year (in 1885) and five extremely wet years (in 1867, 1947, 1967, 1981, 1994). Extremely dry years occurred more often than the extremely wet ones in both half-years (Fig. 4). The extreme sums ranged from 52% of a many-years' average (in 1876) to 155% in a warm half-year (in 1974). Departure from the extreme sums was higher – from 47% (in 1885) to 183% (in 1867) in a cold half-year.

THE YEARS

Extremely dry and extremely wet years did not occur during the analyzed many-years' period (Fig. 3). Very dry (5.7%) and very wet (6.4%) years rarely occurred in the described period. Dry years occurred more often only with 5% in comparison to the wet ones. 44% of the registered years during 140 year period were the average years (Fig. 3). The frequency of extremely dry years was more intensive than the frequency of extremely wet years. The extreme sums ranged from 63% (in 1876) of the many-years' average to 147% (in 1998).

DURATION OF AVERAGE, DRY AND WET PERIODS

The author prepared a comparison of average, dry and wet seasons that occurred during the analyzed a one hundred forty-years period for months, seasons, half-years and year (Fig. 5, Tab. 1). The seasons with an excess or deficiency of precipitation were characterized by very significant changeability. The comparison allows to distinguish the following features (the comparison includes the periods lasting at least 3 years):

1. The longest average period for a year lasted 6 consecutive years (1887-1892), extremely dry for 5 years (1861-1865) and extremely wet for 3 years only (1945-1947).
2. The longest periods with warm half-years extremely dry occurred between 1861-1865 and 1874-1877; extremely wet: 1930-1932, 1934-1936, 1956-1958, 1966-1999; whereas the periods with cold half-years with extremely dry occurred between: 1862-1865, 1875-1877, 1883-1887, 1918-1920, 1926-1930, 1932-1936, 1959-1961; extremely wet: 1866-1868 (most often there were two-year periods). The longest average period lasted 4 years in a warm half-year (1985-1988) and 5 years in a cold half-year (1894-1898).
3. The periods of extremely dry or extremely wet seasons usually lasted 3-4 years. The longest extremely dry period lasted 5 years and occurred in winter (1872-1877). There were more extremely wet periods lasting 5 and more years: there were two five-year periods (1896-1899, 1966-1970) and one seven-year period (1994-2000) in spring and there was one five-year period (1956-1960) in summer. The longest average periods lasted: only two years in spring, 6 years in summer, 3 years in autumn and 4 years in winter.
4. As regards the months, there were longer periods lasting 3-4 years (Fig. 5, Tab. 1):
 - five-year excessively dry periods occurred 18 times. The most often in May and June (3 times each time), they never occurred in January and September. However five-year excessively wet periods occurred only twice (in July and December).
 - six-year excessively dry periods occurred only 10 times (4 times in January and October, once in January and November).
 - seven-year periods occurred 3 times in excessively dry months: in January (1879-1885), March (1923-1929) and November (1955-1961).

The average periods were very short. A six-year period occurred only in July (1890-1895), the longest periods of 3 years occurred in January and August, other periods recorded in the other months lasted 2 years, the only exception remains September with only 1 year.

Since extremely dry and extremely wet periods often occurred in the described many-years' season, the author also analyzed the months that were extremely dry or extremely wet during the consecutive years. After analyzing at least three-year periods, the author distinguished:

- The extremely dry months (the longest periods lasted 3 years): January (1971-1973), February (1913-1915), March (1952-1954), June (1875-1877), August (1973-1975), October (1908-1910, 1943-1945).
- The extremely wet months (there were three-year periods and one four-year period): January (1982-1984), March (1895-1897), June (1980-1982), July (1957-1960).

Table 1

Duration of average, extremely dry and extremely wet periods

Months and seasons	Periods	Duration of average, extremely dry and extremely wet periods (in years)					
		2	3	4	5	6	7
1	2	3	4	5	6	7	8
January	average	2	1	-	-	-	-
	extremely dry	9	1	-	-	4	1
	extremely wet	8	3	1	-	1	-
February	average	3	-	-	-	-	-
	extremely dry	12	3	2	1	-	-
	extremely wet	5	4	1	-	-	-
March	average	3	-	-	-	-	-
	extremely dry	7	6		1	1	1
	extremely wet	4	4	1	-	-	-
April	average	2	-	-	-	-	-
	extremely dry	6	7	2	2	1	-
	extremely wet	8	3	1	-	-	-
May	average	2	-	-	-	-	-
	extremely dry	11	2	3	3	-	-
	extremely wet	6	2	2	-	-	-
June	average	2	-	-	-	-	-
	extremely dry	9	2	1	3	-	-
	extremely wet	5	6	1	-	-	-
July	average	3	2	-	-	1	-
	extremely dry	11	4	3	2	-	-
	extremely wet	7	1	-	1	-	-
August	average	-	1	-	-	-	-
	extremely dry	10	4	1	2	-	-
	extremely wet	8	5	1	-	-	-
September	average	-	-	-	-	-	-
	extremely dry	6	5	3	-	-	-
	extremely wet	5	2	1	1	-	-

1	2	3	4	5	6	7	8
October	average	4	-	-	-	-	-
	extremely dry	8	2	-	1	4	-
	extremely wet	4	3	1	-	-	-
November	average	3	-	-	-	-	-
	extremely dry	4	4	2	1		1
	extremely wet	5	4	-	-	1	-
December	average	1	-	-	-	-	-
	extremely dry	8	5	-	2	-	-
	extremely wet	10	2	1	1	-	-
Spring	average	5	-	-	-	-	-
	extremely dry	5	6	3	-	-	-
	extremely wet	6	-	1	1	-	1
Summer	average	6	2	-	-	1	-
	extremely dry	7	4	1	-	-	-
	extremely wet	8	3	-	1	-	-
Autumn	average	3	2	-	-	-	-
	extremely dry	8	2	4	-	-	-
	extremely wet	6	4	-	-	-	-
Winter	average	2	3	1	-	-	-
	extremely dry	8	1	3	-	1	-
	extremely wet	5	6	1	-	-	-
Warm half-year	average	3	6	1	-	-	-
	extremely dry	4	1	1	1	-	-
	extremely wet	4	3	1	-	-	-
Cold half-year	average	6	-	2	1	-	-
	extremely dry	5	3	1	3	-	-
	extremely wet	7	1	-	-	-	-
Year	average	4	6	2	-	1	-
	extremely dry	4	-	1	1	-	-
	extremely wet	4	1	-	-	-	-

CONCLUSION

The results of the analysis concerning the frequency of average, dry and wet periods recorded in Lębork for a year, half-years, seasons and months show that:

1. The extremely dry years, half-years, seasons and months occurred more often than the extremely wet ones during a period between 1861 and 2000.
2. As regards the annual sums there were no extremely dry and extremely wet years, whereas the frequency of the extremely dry years was 5% higher than the frequency of the extremely wet years.
3. The extremely dry years did not occur in a warm half-year, however there were the extremely wet years. There were more considerable differences – there was 1 extremely dry year and 5 extremely wet years.
4. The results show that most of all average years occurred in summer, excessively dry – in spring and excessively wet – in winter.
5. The monthly sums were characterized by a decreased frequency of the average months and an increased frequency of the extremely dry and extremely wet months. The most of the extremely dry months recorded in the analyzed many-years' period occurred in March, April and October, whereas the extremely wet in June, August, September, November and December. The highest fluctuations in respect of a many-years' average occurred in October (3-329%).
6. Determining of duration of average, dry and wet periods confirms considerable changeability of consecutive periods with an excess or deficiency of precipitation:
 - The longest periods lasted 7 years and occurred 3 times in the excessively dry months (January, March, November) and once in spring, that was extremely wet.
 - In general the extremely dry periods lasted longer than the extremely wet ones.
 - The average periods were very short. A six-year period occurred only in July (1890-1895), the longest periods of 3 years occurred in January and August, other periods recorded in the other months lasted 2 years, the only exception remains September with only 1 year.
 - There were years with all extremely dry or extremely wet seasons, half-years and year (or with only one average season, a number of the extremely dry and wet months provided in brackets). The extremely dry years: 1864 (8), 1865 (9), 1870 (8), 1875 (10), 1876 (8), 1877 (6), 1881 (10), 1884 (9), 1886 (8), 1964 (10), 1975 (7). The extremely wet years: 1882 (8), 1867 (7), 1958 (5), 1967 (9), 1981 (6), 1998 (10).

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CZĘSTOŚĆ OKRESÓW NORMALNYCH I ANORMALNYCH SUM OPADÓW ATMOSFERYCZNYCH W LĘBORKU W LATACH 1861-2000

Streszczenie

Przeprowadzono ocenę częstości pojawiania się okresów przeciętnych, suchych i wilgotnych dla miesięcy, pór roku, półroczy i roku. Ponadto, zestawienie danych ze 140 lat (1861-2000) daje możliwość sprawdzenia, w jaki sposób układały się lata nadmiernie wilgotne i nadmiernie suche. W opracowaniu przyjęto klasyfikację Z. Kaczorowskiej (1962).

Na podstawie przeprowadzonej analizy udowodniono, że w okresie 1861-2000 częściej występowały lata, półrocza, pory roku i miesiące nadmiernie suche niż nadmiernie wilgotne. W przypadku sum rocznych nie wystąpiły lata skrajnie suche i skrajnie wilgotne, a częstość lat nadmiernie suchych była o 4% większa niż nadmiernie wilgotnych. W półroczu ciepłym również nie wystąpiły lata skrajnie suche, ale pojawiły się lata skrajnie wilgotne. W półroczu chłodnym różnice były większe – wystąpił 1 rok skrajnie suchy i 5 lat skrajnie wilgotnych. Z porównania pór roku wynika, że najczęściej przeciętnych lat wystąpiło – latem, nadmiernie suchych – wiosną i nadmiernie wilgotnych – zimą. Sumy miesięczne charakteryzowały się zmniejszeniem częstości przeciętnych miesięcy i wzrostem skrajnie suchych oraz skrajnie wilgotnych. Najwięcej miesięcy skrajnie suchych wystąpiło w marcu, kwietniu i październiku, natomiast skrajnie wilgotnych – w czerwcu, sierpniu, wrześniu, listopadzie i grudniu. Największe wahania względem średniej wieloletniej wystąpiły w październiku (3-329%).

Określenie czasu trwania okresów przeciętnych, suchych i wilgotnych potwierdza bardzo dużą zmienność występujących po sobie okresów z nadmiarem lub niedoborem opadów:

- najdłuższe okresy trwały 7 lat i wystąpiły 3 razy w miesiącach nadmiernie suchych (styczeń, marzec, listopad) oraz 1 raz wiosną, która była nadmiernie wilgotna,
- na ogół okresy nadmiernie suche trwały dłużej niż nadmiernie wilgotne,
- bardzo krótko trwały okresy przeciętne. Tylko w lipcu wystąpił okres sześciolatej (1890-1895), w styczniu i sierpniu najdłuższe okresy trwały 3 lata, w pozostałych miesiącach 2 lata, wyjątek stanowi wrzesień, w którym okres nie był dłuższy niż rok.