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Dry and Wet Spells in Poland in the Period 1966–2023

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Abstract: The aim of this study is to present the spatial and temporal variability of the frequency of dry and wet days and dry and wet spells against the background of changes in precipitation and atmospheric circulation. The study is based on daily precipitation totals from 46 meteorological stations in Poland from 1966 to 2023. Additionally, seven circulation indices were used, namely GBI, NAO, AO, EA, EA/WR, SCAND, and AMO. Dry days are defined as days without precipitation. Wet days are days with at least 1 mm of precipitation. It was shown that dry spells are much more common than wet spells, are longer, and cover larger areas. Long-term changes in the annual characteristics of dry and wet days and spells are not statistically significant. Only the length of the most extended dry spell in the year increases. However, there are significant changes in their annual cycles. Spring is drier; in summer, precipitation decreases in the south and increases in the north; November and December, symbols of gloomy rainy weather, are increasingly drier; and rainy weather has shifted to January and February. The impact of circulation varies according to the season, with the NAO, AO, SCAND, and GBI indices having the greatest influence.

Keywords: dry day; wet day; precipitation; interannual variability; trend; atmospheric circulation

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Citation: Wibig, J. Dry and Wet Spells in Poland in the Period 1966–2023. *Water* **2024**, *16*, 1344. https://doi.org/10.3390/w16101344

Academic Editor: Paul Kucera

Received: 15 April 2024
Revised: 26 April 2024
Accepted: 6 May 2024
Published: 8 May 2024

1. Introduction

Over the last few decades, mean and heavy precipitation changes have been documented in Europe [1–3] and in particular regions of Europe [4–8]. The effect of heavy rainfall depends not only on its intensity but also on whether the days with rainfall are evenly distributed over time or whether they occur as consecutive days with rain, so-called wet spells [9,10]. Furthermore, the wet spells and their opposite, dry spells, together determine the European hydroclimate. Prolonged dry weather has negative impacts on society, including water security, wildfire risk, agriculture, and energy production. Extreme dry spells contribute to meteorological, agricultural, and hydrological droughts. Dry spells negatively affect water quality, and in combination with high temperatures, they can cause toxic algal blooms, which also decrease the oxygen content in the water [11–13], threatening the lives of fish and other aquatic organisms. Prolonged wet weather, on the other hand, may favor flooding.

Wet and dry spell analysis usually includes their duration and frequency of occurrence [10,14,15]. However, the time of their occurrence during the year is also essential. Changes in the timing of dry and wet spells have rarely been analyzed; their occurrence during the vegetation period is much more dangerous than during the rest of the year.

Contemporary warming significantly affects precipitation, not so much of its total, but to a much greater extent, in its distribution [16]. There are many signs that precipitation events have become less frequent [17], more intense [18], and with higher extremes [19,20]. Studies examining dry and wet spell durations have presented that trends differ at different locations. Groisman and Knight [21] have shown that the average duration of dry episodes during the warm season in the Central United States has significantly increased. Similar results were found in the Southwestern United States by Mc Cabe et al. [22] and in Argentina by Llano and Penalba [23]. In Europe, Schmidli and Frei [7] have shown an increase in dry spell duration in Southern Switzerland, but only in spring. Zolina et al. [10] have found that the duration of dry spells decreases in Scandinavia and Southern Europe during both winter and summer. However, in the Netherlands, dry periods are longer during both the warm and cold seasons. Breinl et al. [11] analyzed the most extended dry spells in Western, Southern, and Northern Europe. They have shown that the declining trends dominate in Northern Europe, while in Southern and Central Europe they are very diverse.

According to the wet spells, Zolina et al. [10] have shown the growth in their duration in Northern Europe and Central European Russia in winter and over the Netherlands during both winter and summer. In summer, wet spells have become shorter over Northern Russia and Scandinavia. Schmidli and Frei [7] and Wibig [14] showed an increase in wet-spell duration in the second half of the 20th century over the Swiss Alps and in Poland.

Paton [24] has shown that the choice of spell definition significantly impacts the result. She suggested using precise definitions and being very careful when comparing results in the case of different definitions.

In Poland, dry and wet spells based on consecutive days with precipitation < 0.1 mm or >0 mm [17] or the Standardized Precipitation Index (SPI) [25,26] were used, but there was a lack of papers on the spatial and temporal variability of the frequency of dry and wet days and spells. Dry spells occurred in Poland at a clear dominance of anticyclonic weather, wet in cyclonic circulation with advections from the south and west [26]. The aim of this study is to fill this gap and present the spatial and temporal variability of the frequency of dry and wet days and spells against the background of changes in precipitation and atmospheric circulation. The data and methods used in this study are described in Section 2. Section 3 presents the following: spatial distribution and trends of precipitation (Section 3.1), dry day frequencies and their changes (Section 3.2), dry spell frequency changes (Section 3.3), wet day frequencies and their changes (Section 3.4), wet spell frequency changes (Section 3.5), and relations of dry and wet day frequencies with selected atmospheric circulation indices (Section 3.6). The discussion and summary are provided in Section 4.

2. Data and Methods

The study is based on daily precipitation totals from 46 meteorological stations in Poland from 1966 to 2023. Their locations are presented in Figure 1. The data are provided by the Institute of Meteorology and Water Management-National Research Institute (IMWM-NRI). Stations with complete data series and located below 1000 m a.s.l. were selected. From 1966 to 2023, site relocation was restricted within 1 km horizontally and 10 m vertically. Poland is a lowland country; the areas situated above 1000 m a.s.l. are less than 1%.

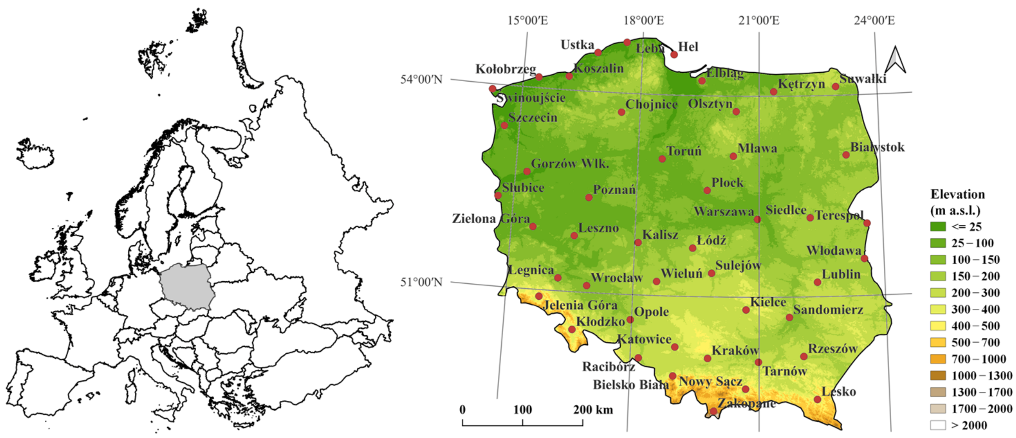

Figure 1. Location of meteorological stations.

Seven circulation indices were used to investigate the influence of atmospheric circulation on precipitation and dry and wet day frequencies in Poland. The list is presented in Table 1.

Table 1. List of circulation indices.

Full Name	Abbrev.	Source	Ref.
Greenland Blocking Index	GBI	https://psl.noaa.gov/gcos_wgsp/Timeseries/Data/gbi.mon.data (accessed on 13 April 2024)	[27]
Atlantic Multidecadal Oscillations	AMO	https://www1.ncdc.noaa.gov/pub/data/cmb/ersst/v5/index/ersst.v5.amo.dat (accessed on 13 April 2024)	[28]
Arctic Oscillation	AO	https://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/monthly.ao.index.b50.current.ascii (accessed on 13 April 2024)	-
North Atlantic Oscillation	NAO	https://ftp.cpc.ncep.noaa.gov/wd52dg/data/indices/tele_index.nh (accessed on 13 April 2024)	[29]
Scandinavian Index	SCAND	https://ftp.cpc.ncep.noaa.gov/wd52dg/data/indices/tele_index.nh (accessed on 13 April 2024)	[29]
East Atlantic Index	EA	https://ftp.cpc.ncep.noaa.gov/wd52dg/data/indices/tele_index.nh (accessed on 13 April 2024)	[29]
Eastern Europe/Western Russia	EA/WR	https://ftp.cpc.ncep.noaa.gov/wd52dg/data/indices/tele_index.nh (accessed on 13 April 2024)	[29]

IMWM-NRI provides daily precipitation totals with an accuracy of 0.1 mm. In addition, they provide information on so-called unmeasurable precipitation when its sum is less than 0.1 mm. In this paper, dry days are defined as days with precipitation below 0.1 mm, and days with precipitation of at least 1 mm are defined as wet days. The threshold of 1 mm in the definition of wet days was applied for easier comparison with studies in other regions [15,30]. However, the days with precipitation between 0.1 and 0.9 mm were not analyzed. A dry spell at particular stations was defined as a sequence of at least seven consecutive dry days between the two nearest dates on which at least 0.1 mm of precipitation was recorded. A dry spell in Poland was defined as a sequence of at least seven consecutive days in which dry spells continued over at least 12 stations. A condition of 12 stations was chosen because it means that it is dry in an area covering more than 25% of the country. In the further part of this study, a dry spell is solely considered as a dry spell in Poland.

Adopting similar conditions in the definition of a wet spell caused only a few wet spells to be distinguished in the analyzed period. The requirements had to be significantly lowered. Ultimately, a wet spell at particular stations was defined as a sequence of at least five consecutive wet days between the two nearest dates on which precipitation below 1 mm was recorded. A wet spell in Poland was defined as a sequence of at least five consecutive days in which wet spells persisted at least nine stations. A condition of nine stations means it is wet in an area covering about 20% of the country. As in the case of dry spell, in the further part of this study, wet spell specifically refers to wet spell in Poland.

Trends in the monthly values of precipitation and dry and wet days at the stations were calculated using the Sen–Theil estimator of slope [31,32] and the Mann–Kendall test [33]. Both are nonparametric methods that do not require a normal distribution of the analyzed time series. Non-parametric statistics are much less affected by outliers and give robust results for non-normally distributed series [33].

Pearson's correlation coefficient was used to analyze the relationships between the atmospheric circulation and the area average values of the monthly precipitation totals and monthly frequencies of dry and wet days. The area average values were calculated as averages of all the stations. The statistical significance of all the tests was assessed at the 0.05% level. All maps were prepared in Surfer 20 using the kriging method.

3. Results

3.1. Precipitation Totals and Their Long-Term Changes

In the analyzed period, the average annual precipitation in Poland in the area below 1000 m a.s.l. was 623 mm. Its spatial distribution strongly depends on terrain and is the lowest in Central Poland, reaching a minimum in Kalisz amounting to 501 mm. On the coast and Lakeland hills in Northern Poland, precipitation is of the order of magnitude of 600–700 mm, similar to Southern Poland. In the foothills, it exceeds 800 mm, reaching 1132 mm in Zakopane, the southernmost part of the country (Figure 2A). Long-term changes in precipitation are small. In the western part of the country, precipitation increases slightly, and in the eastern part, it decreases (Figure 2B). Changes rarely exceed 2 mm y^{-1}, which, given the high variability from year to year, means that they are mostly statistically insignificant. From 46 analyzed stations, precipitation increased significantly at 6 and decreased significantly at 2.

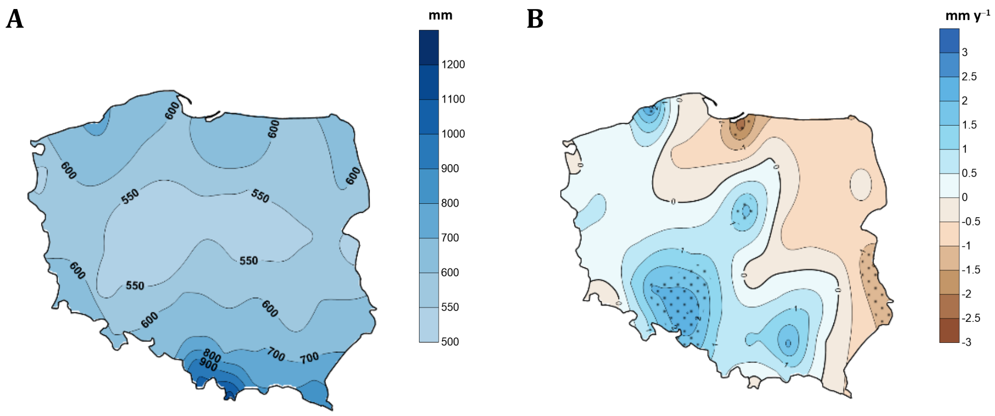

Figure 2. Average annual precipitation totals in Poland from 1966 to 2023 (**A**) and their long-term trends (**B**). Areas with statistically significant trends are dotted.

The annual precipitation pattern in Poland is typical for the continent's interior in the temperate zone. The lowest precipitation was observed in January and February, averaging around 33 and 30 mm, respectively. The highest precipitation occurs in July, averaging around 87 mm (Figure 3). Long-term precipitation trends are generally small but vary over the year and space. In the winter, precipitation increases in the north and east, statistically significant in vast areas, and slightly decreases in the south. In spring, rainfall changes are insignificant in all months except April, when they decrease significantly in the west of the country. Summer begins with a significant decrease in rainfall in the center of the country and in the south. Then, in July, there is a slight increase in rainfall in the north and west. In August, there is a significant increase in the rainfall in the north and a decrease in the south. In the first autumn month, September, the picture is exactly opposite of August. Rainfall decreases in the north and increases in the south. In October, the changes are small and non-significant, and in November, the precipitation strongly decreases throughout the country.

3.2. Dry Days

There are, on average, 195 dry days in Poland, which is slightly more than half of all days. Based on the individual stations, this number ranges from 183 in Bielsko-Biała in the south of Poland to 211 in Kalisz in the central part of the country. In the annual course, the lowest number of dry days occurred in December, at 13.9, and the highest in August, at about 18.4. The average numbers of dry days in Poland from 1966 to 2023 are presented in Figure 4. There is a large variability of such days from year to year. The smallest number of dry days occurred in 1967, when there were 158 such days. The highest number of dry days occurred in 1982, when there were as many as 235 of them. The number of dry days increased slightly in the analyzed period, with the rate of 1.5 days per 10 years, but the change was not statistically significant.

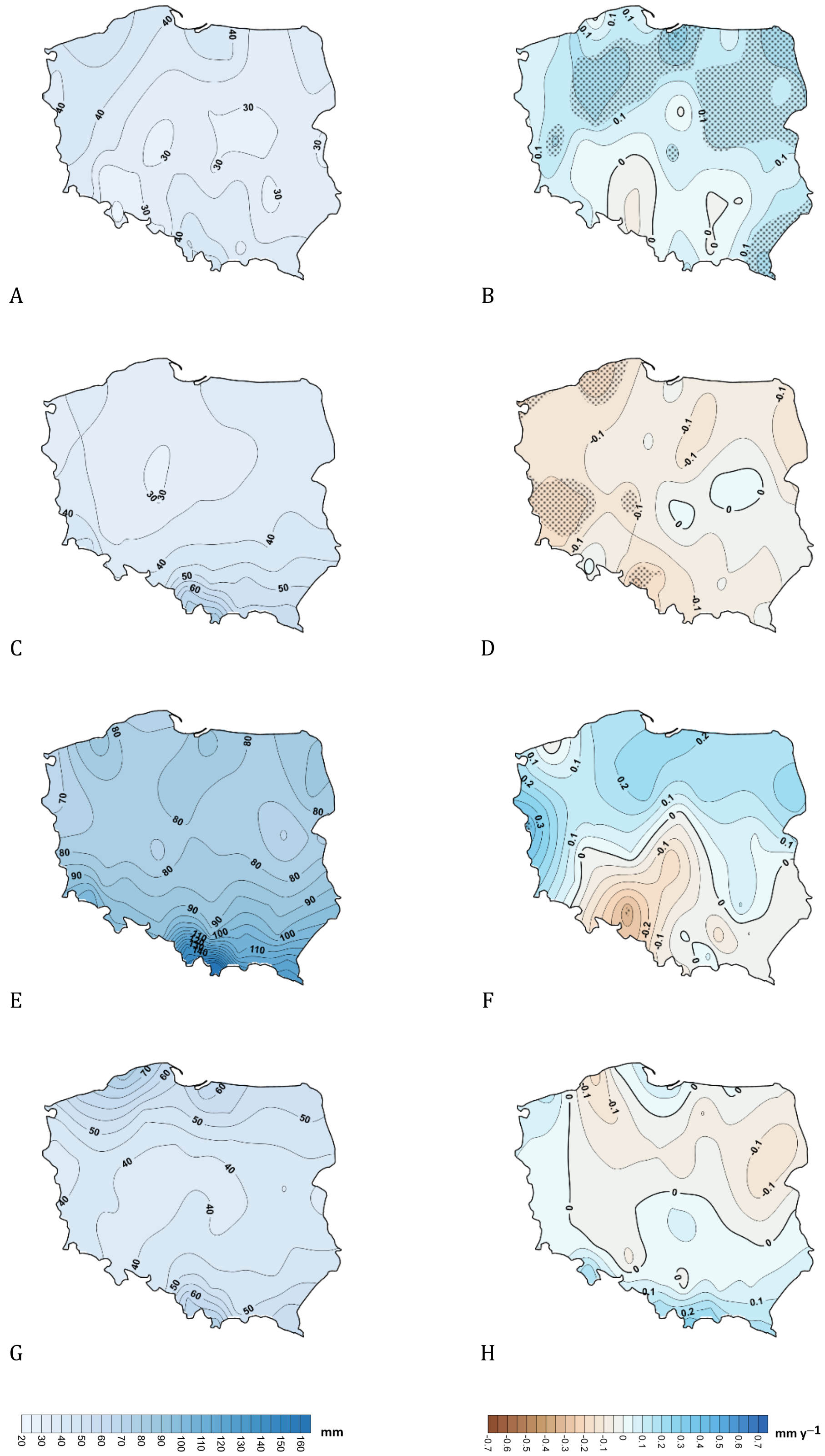

Figure 3. Average monthly precipitation sums and their trends in 1966–2023, (**A**,**B**)—January, (**C**,**D**)—April, (**E**,**F**)—July, (**G**,**H**)—October. The areas of statistically significant trends are dotted.

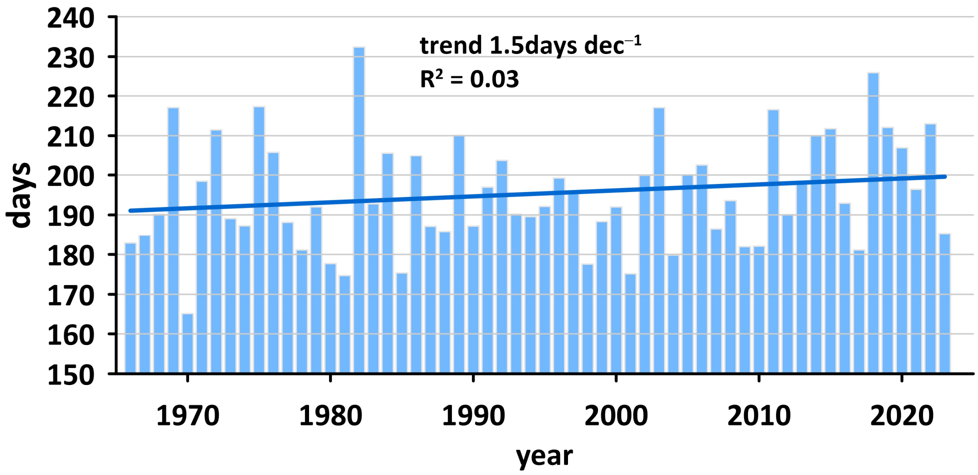

Figure 4. The annual numbers of dry days averaged in Poland in the period of 1966–2023 with the linear trend line.

Trends in the number of dry days are characterized by high spatial variability and are different in different months. A few examples are shown in Figure 5. In January, decreasing trends dominate, and in some places, they are statistically significant. A patchy pattern is apparent in February, May, and October, with small and insignificant changes. In April, positive trends appear to dominate, and at the seaside, they are significant. The number of dry days is also increasing in June. And around this time, significant changes occurred in the south. In August, the decrease in dry days occurs in the north, is significant at the seaside, and increases are in the south. A precisely opposite picture of changes is observed in September. Here, a significant increase in dry days occurs in Northern Poland. In November and December, the increasing trend in the number of dry days is visible and statistically significant over a large area. This is an essential change because these two months were characterized by the lowest frequency of dry days. What is also disturbing is the increase in the number of dry days at the beginning and in the first part of the growing season in April and June.

3.3. Dry Spells

Based on the adopted definition, 476 dry spells were distinguished in the analyzed period, with an average of 8.2 per year. There are a total of 5601 days in these spells, and 96.5 per year on average. It means that dry spells cover more than 26% of all days. The distribution of spells depending on their duration is presented in Figure 6, and the ten longest ones are summarized in Table 2. The number of spells quickly decreases as their length increases, with the longest spell lasting 43 days, and the tenth spell lasting only 29 days. 36 spells lasted at least 20 days, and 271 lasted at least 10 days.

Only two of the ten longest-lasting spells occurred before 2000, and the remaining eight occurred in 2000–2023. Moreover, six occurred in April, May, or June, i.e., at the beginning and in the first part of the growing season. The spatial extent of dry spells is measured by the number of stations where no rainfall is recorded. For each dry spell day, the number of stations where no precipitation was recorded was calculated, and the results are illustrated in Figure 7. The lack of precipitation is noticed in 13–19 stations over more than 200 days. In more than 150 days, the lack of precipitation is observed at 12, 17–19, 26, and all 46 stations. In the remaining cases, the number of days varied from 89 to 150.

The most extended dry spell in the year varied from 11 in 1967 and 1970 to 43 days in 2011. A statistically significant increase of 1.6 days per 10 years is observed (Figure 8A). The average annual number of dry spell days varied widely from 37 in 1970 to 183 days in 1982. The year-by-year fluctuations are high, but no long-term trend is observed (Figure 8B).

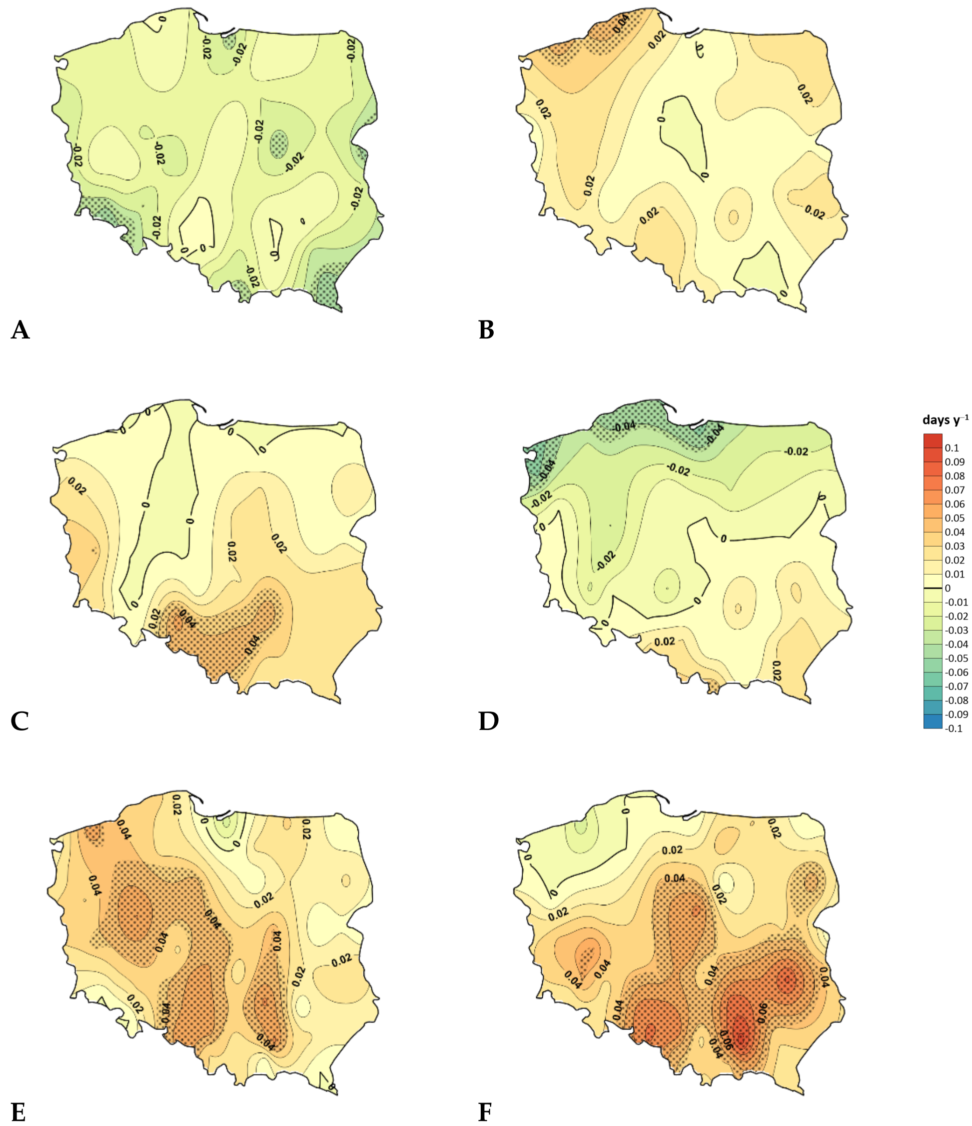

Figure 5. Trends in the number of dry days in six selected months in Poland in the period of 1966–2023; January (**A**), April (**B**), June (**C**), August (**D**), November (**E**), and December (**F**). Areas with statistically significant changes are dotted.

Table 2. Ten of the longest-lasting dry spells in Poland.

Number	Begin	End	Length in Days
1	21 October 2011	2 December 2011	43
2	29 March 2009	5 May 2009	38
3	24 February 2022	2 April 2022	38
4	19 March 1974	19 April 1974	32
5	28 June 2006	29 July 2006	32
6	17 April 2000	17 May 2000	31
7	28 March 2019	27 April 2019	31
8	15 August 2002	13 September 2002	30
9	7 February 2003	8 March 2003	30
10	12 May 1992	9 June 1992	29

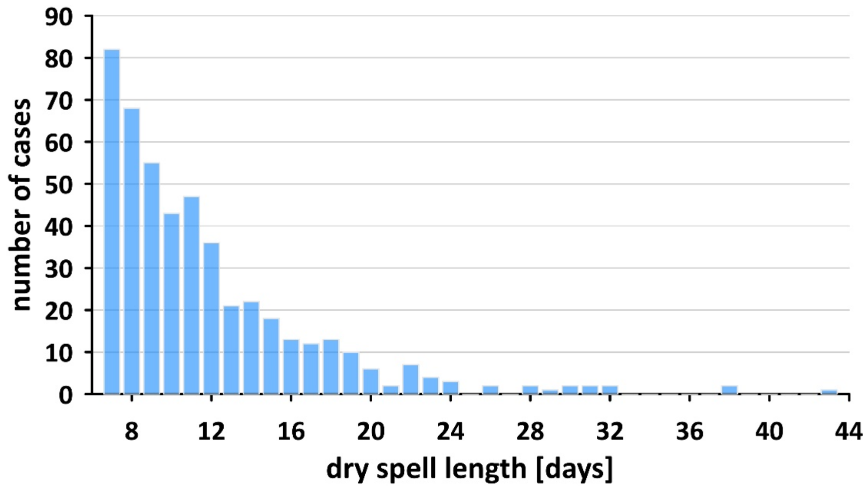

Figure 6. The distribution of dry spells in relation to their length.

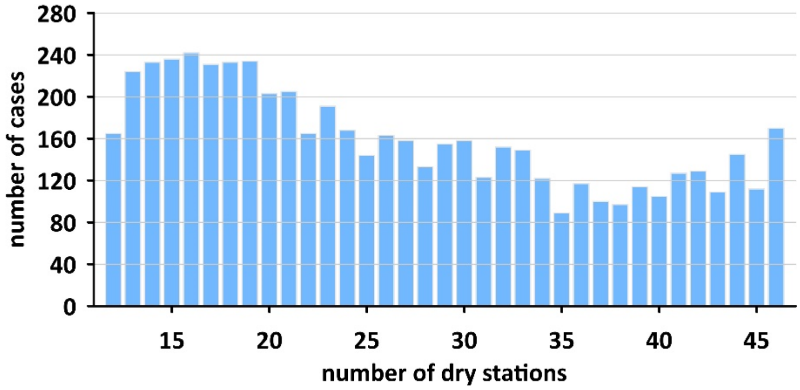

Figure 7. The number of dry spell days depending on the number of stations where no precipitation was recorded.

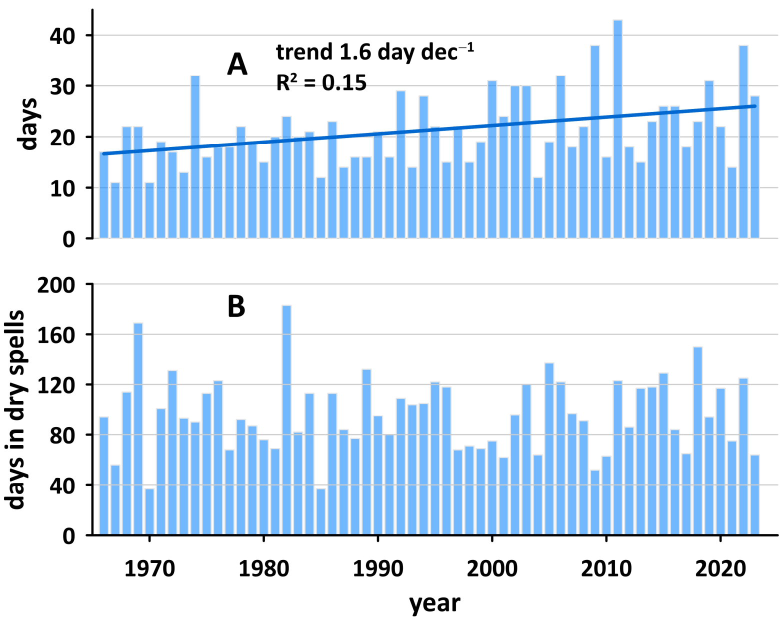

Figure 8. The length of the longest spell in the year (**A**) and the annual number of dry spell days (**B**).

3.4. Wet Days

Poland has significantly fewer days with precipitation of 1 mm or higher (later called wet days) than dry days. There are, on average, 105 wet days, which is slightly less than 30% of all days. Regarding the individual stations, this number ranges from 81 in Legnica to 128 in Gorzów. In the annual course, the lowest number of wet days occurred in February and April, at 7.6, and the highest in July, at about 10.2. The average number of wet days in Poland from 1966 to 2023 is shown in Figure 9. There is a large year-by-year variability of such days. The smallest number of wet days occurred in 1982 when there were 81 such days. It was also the year with the highest number of days without precipitation. The wettest days were in 1970, when there were as many as 128 of them. The number of wet days decreased slightly in the analyzed period with the rate of −0.08 days per 10 years, but the change was not statistically significant.

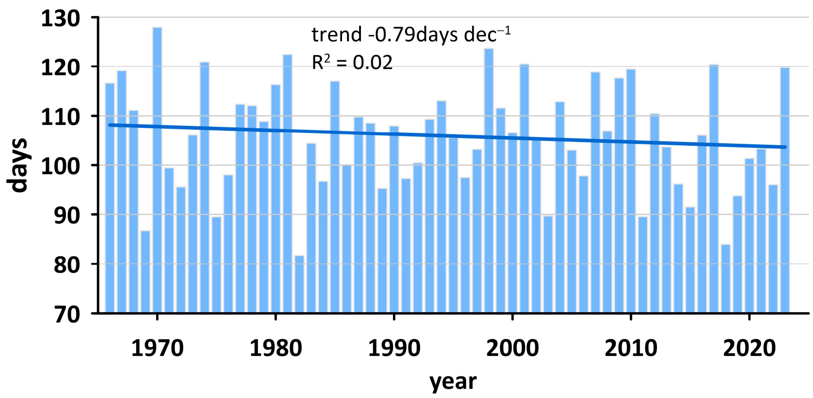

Figure 9. The annual numbers of wet days averaged in Poland in the period of 1966–2023 with the linear trend line.

3.5. Wet Spells

Based on the adopted definition, 200 wet spells were distinguished in the analyzed period, on average less than 4 per year. There were a total of 1236 days in these spells, which was an average of 21.3 per year. Even though the definition of wet spells is much less demanding, there are definitely fewer of them. It means that wet spells cover less than 6% of all days. The distribution of spells depending on their duration is presented in Figure 10, and the nine longest ones are summarized in Table 3. The number of spells quickly decreases as their length increases (Figure 11). The longest spell lasted fourteen days, and the tenth spell lasted only nine days. They are much shorter in comparison with dry spells.

Table 3. Nine of the longest wet spells in Poland.

Number	Begin	End	Length in Days	Precipitation in mm
1	29 June 1980	12 July 1980	14	121
2	19 October 2002	30 October 2002	12	60
3	4 December 1988	14 December 1988	11	43
4	26 August 1995	5 September 1995	11	128
5	25 October 1998	4 November 1998	11	60
6	7 September 2001	17 September 2001	11	87
7	28 February 1998	9 March 1998	10	38
8	27 May 2013	5 June 2013	10	91
9	8 May 2014	17 May 2014	10	117

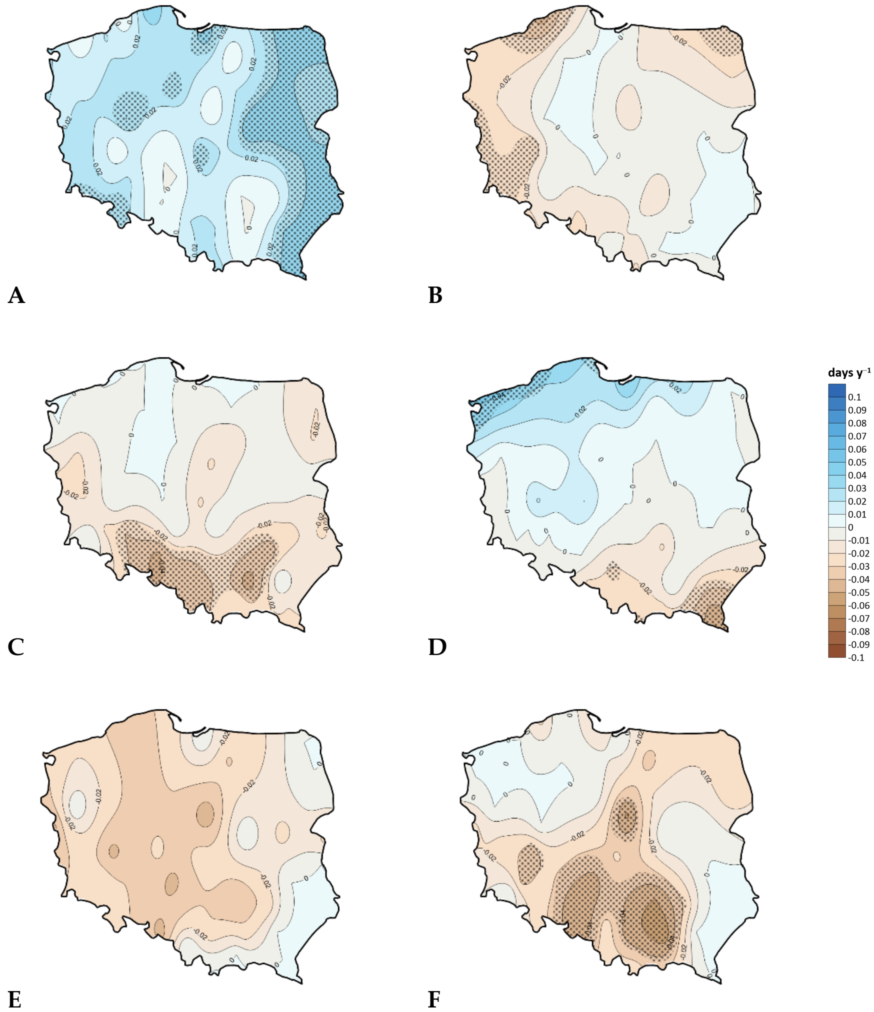

Figure 10. Trends in the number of wet days in six selected months in Poland in the period of 1966–2023; January (**A**), April (**B**), June (**C**), August (**D**), November (**E**) and December (**F**). Areas with statistically significant changes are dotted.

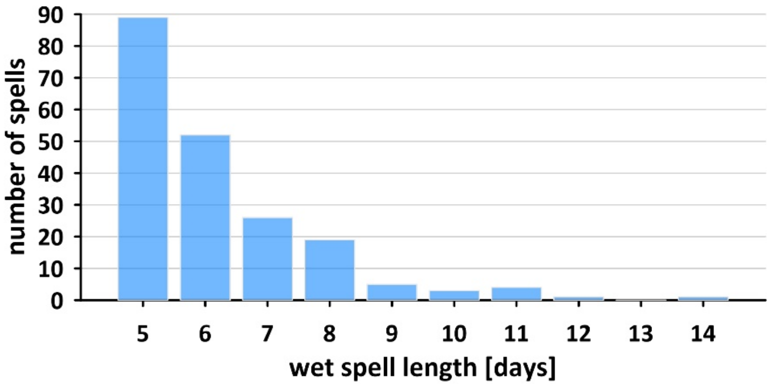

Figure 11. The distribution of wet spells in relation to their length.

The nine longest spells occurred in the middle of the analyzed period, between 1980 and 2014. Two of them were recorded in the same year, 1998. Five occurred in autumn and early winter, and only three during the growing season. Only three of the wet spell precipitation totals were higher than 100 mm. The spatial extent of wet spells, measured by the number of stations where at least 1 mm of precipitation was observed, is generally lower than the area covered by dry spells (Figure 12). The greatest coverage of wet spells reached 34 stations out of 46, which is less than 74% of the country's area. Only 86 spells cover more than half of the country, i.e., less than 2 wet spells per year.

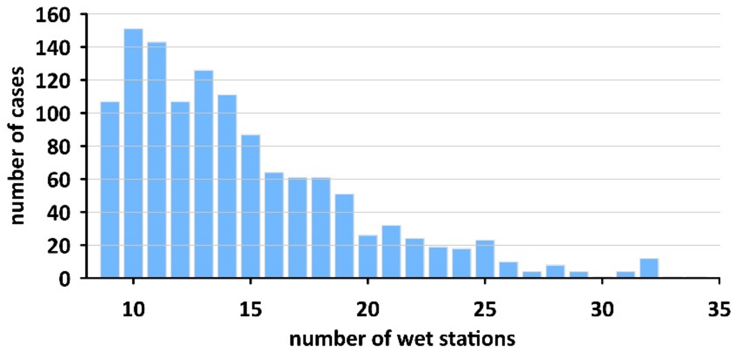

Figure 12. The number of wet spell days depending on the number of stations where at least 1 mm of precipitation was recorded.

The longest wet spell in the year varied from 5 in 9 years, uniformly distributed in the analyzed period, to 14 in 1980 (Figure 13B). The average annual number of wet spell days was 21.3, and this varied widely from 4 in 2005 (the only wet spell started in the previous year) to 55 days in 1998 when two very long wet spells occurred. The year-by-year fluctuations are very high, but a long-term trend is not found (Figure 13C). The annual total precipitation in wet spells expressed as a percentage of average annual precipitation varied from 3.2% in 2005 to more than 61.2% in 1997 when there was extended flooding in the Odra Valley in Western Poland (Figure 13A). Over 50% of the average annual precipitation in wet spells also occurred in 2001 (54.3%) and 1998 (52.0%).

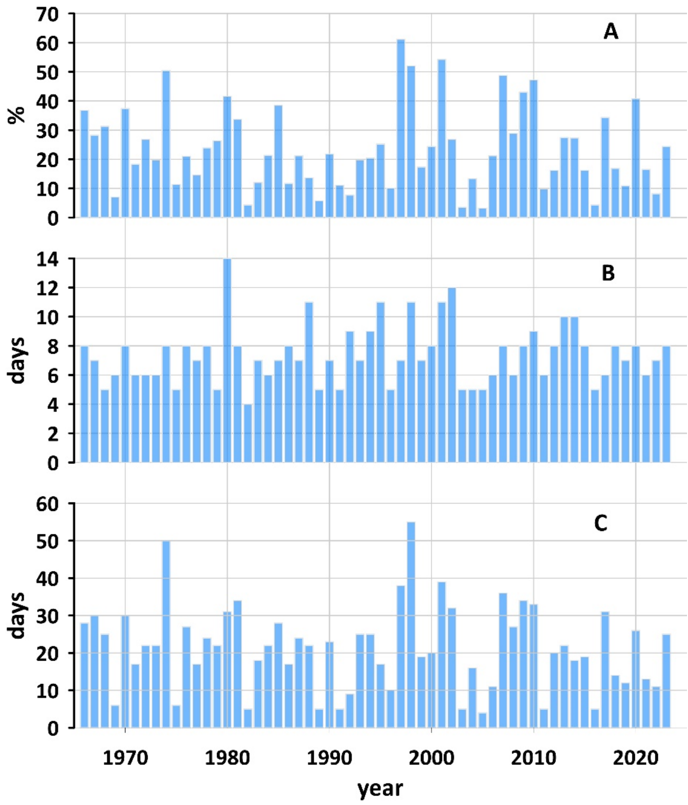

Figure 13. The total precipitation in wet spells expressed as a percentage of average annual precipitation (**A**), the duration of the longest wet spell in the year (**B**), and the annual number of wet spell days (**C**).

3.6. Relation of Dry and Wet Spells with Atmospheric Circulation

The purpose of this section was to provide a preliminary analysis of the relationships between wet/dry spells and atmospheric circulation that can be expected. This is a type of reconnaissance before undertaking detailed research. It was assumed that if a particular type of circulation favors the occurrence of dry or humid days, the effect should be visible in an area larger than the station's surroundings. Therefore, average area rainfall sums and the frequency of dry and humid days were calculated. A wide range of circulation indices that could affect precipitation rates in Poland were selected. They were the Atlantic Multidecadal Oscillation (AMO), the Greenland Blocking Index (GBI), the North Atlantic Oscillation (NAO), the East Atlantic pattern (EA), the Scandinavian pattern (SCAND), the East Atlantic/Western Russia pattern (EA/WR and the Arctic Oscillation (AO). Then, Pearson's correlation coefficients were calculated. Tables 4–6 contain the correlation coefficients between the precipitation totals (Table 4), dry day frequencies (Table 5), and wet day frequencies (Table 6).

Table 4. Correlation coefficients between monthly precipitation totals averaged over all stations in Poland and selected circulation indices. Statistically significant correlation values are bolded.

Month	AMO	GBI	NAO	EA	SCAND	EA/WR	AO
January	0.15	0.01	0.14	−0.15	**−0.50**	−0.12	0.05
February	**0.35**	0.00	0.10	0.17	**−0.54**	−0.12	0.14
March	0.11	0.10	0.03	0.05	**−0.36**	−0.24	−0.02
April	−0.07	0.04	−0.03	0.22	−0.02	**−0.36**	−0.04
May	0.02	0.23	−0.20	0.02	0.02	**−0.31**	−0.13
June	−0.11	0.13	−0.22	−0.10	0.24	−0.17	−0.22
July	0.04	0.11	−0.22	0.11	**0.41**	**−0.29**	−0.07
August	0.12	**0.35**	**−0.31**	0.02	0.15	−0.23	**−0.35**
September	0.03	**0.27**	**−0.28**	**−0.35**	0.22	−0.11	**−0.59**
October	0.01	0.24	−0.17	**−0.25**	−0.15	−0.22	**−0.36**
November	0.06	0.25	**−0.41**	0.03	**−0.30**	**−0.39**	−0.10
December	−0.06	0.07	0.23	−0.05	0.02	0.03	−0.09

Table 5. Correlation coefficients between monthly dry day frequencies averaged over all stations in Poland and selected circulation indices. Statistically significant correlation values are in bold.

Month	AMO	GBI	NAO	EA	SCAND	EA/WR	AO
January	−0.07	−0.06	−0.10	0.19	**0.60**	0.17	−0.01
February	−0.15	−0.17	0.06	0.02	**0.49**	0.14	0.10
March	0.02	−0.14	0.03	0.19	**0.30**	**0.28**	0.06
April	0.09	0.02	0.01	−0.08	0.21	**0.44**	0.02
May	0.09	**−0.25**	0.23	0.04	0.03	0.20	0.23
June	0.11	**−0.29**	**0.40**	0.12	0.05	0.08	**0.35**
July	−0.05	**−0.27**	**0.37**	−0.02	−0.14	**0.29**	0.20
August	−0.21	**−0.37**	**0.41**	−0.03	0.10	0.20	**0.29**
September	0.16	**−0.26**	**0.28**	**0.48**	0.01	−0.14	**0.49**
October	−0.04	−0.24	0.21	0.20	**0.34**	0.10	**0.26**
November	0.04	−0.18	**0.34**	0.08	**0.53**	**0.46**	0.05
December	0.12	−0.08	−0.15	0.18	0.02	0.00	0.07

AMO represents the temperature of the North Atlantic and only has an indirect impact by heating and humidifying the air masses flowing over Poland from the Atlantic. Its effect on precipitation and wet and dry day frequencies is only probable in February because at a significance level of 5%, a single significant result in 12 attempts can happen by chance. There is a slightly greater probability that the EA type influences precipitation in early autumn. The EA type in the positive phase is characterized by the presence of a low-pressure system over the North Atlantic (NA) and a high-pressure wedge reaching from the Azores High area over Poland and further to the northeast. This increased pressure may lead to lower precipitation, fewer wet days, and more dry days. GBI is associated with the presence of an anticyclone in Greenland. In Poland, it favors a lower frequency of dry days in the warm season from May to September and, at the same time, to a slightly lesser extent, higher rainfall, and a higher frequency of wet days. NAO and AO are associated with a slightly higher frequency of dry days in the summer and autumn, and at the same time, with lower rainfall and a lower frequency of wet days. Type EA/WR in the positive phase is characterized by the presence of two low-pressure systems, one over the North Atlantic (NA) and a second over Western Russia. High-pressure systems are present in Western and Central Europe. This increased pressure may promote lower precipitation, fewer wet days, and more dry days. The Scandinavian pattern in its positive phase is characterized by the high-pressure system over Scandinavia. In the cold season, from October to March, except December, this type favors lower precipitation, fewer wet days, and more dry days.

Table 6. Correlation coefficients between monthly wet day frequencies averaged over all stations in Poland and selected circulation indices. Statistically significant correlation values are in bold.

Month	AMO	GBI	NAO	EA	SCAND	EA/WR	AO
January	0.15	0.02	0.17	−0.19	**−0.53**	−0.15	0.03
February	**0.28**	0.01	0.10	0.07	**−0.58**	−0.12	0.10
March	0.06	0.07	0.05	−0.05	**−0.38**	−0.25	0.05
April	−0.07	0.01	−0.02	0.09	−0.17	**−0.41**	−0.04
May	−0.07	0.23	−0.17	−0.01	0.00	−0.18	−0.19
June	−0.12	**0.28**	**−0.39**	−0.13	−0.01	−0.09	**−0.34**
July	0.02	0.23	**−0.34**	0.02	0.20	**−0.28**	−0.17
August	0.18	**0.35**	**−0.38**	0.03	−0.05	−0.19	**−0.28**
September	−0.11	**0.25**	**−0.26**	**−0.46**	0.07	0.07	**−0.54**
October	0.03	0.25	−0.2	−0.19	**−0.31**	−0.13	**−0.29**
November	−0.02	0.20	**−0.37**	−0.06	**−0.46**	**−0.41**	−0.09
December	−0.12	0.08	0.19	−0.08	0.01	0.01	−0.08

On the other hand, looking at particular months, it is clear that precipitation in December is resistant to the influence of the studied circulation indices. In turn, at the turn of summer and autumn, in September and August, these influences tend to be the most visible.

4. Discussion and Summary

The average annual precipitation total has not changed considerably in Poland. This is well visible when comparing the average annual total in the period of 1966–2023 from this study (623 mm) with the following results of other authors and different periods: 633 mm in 1881–1900 [34], 605 in 1901–1980 [35], 601 mm in 1891–1990, and 606 in 1951–1970 [36], 590 mm in 1951–2000 [37]. Similar results were observed in neighboring countries. In Germany, Brienen et al. [38] noticed that tendencies in precipitation in Germany over the 20th century are variable and very sensitive to the considered period. It was shown that since 1950, annual precipitation has increased in Northern Europe and decreased in part of Southern Europe [39]. However, despite the lack of significant changes in annual rainfall totals, many studies indicate that changes in precipitation in Germany depend on the season or even the month [40,41]. Many authors point out that the seasonality of rainfall changes; winter rainfall increases, and summer precipitation decreases [34,40,42,43].

Moving to a monthly time scale revealed that changes in individual seasons are not uniform. Winter begins in December, during which monthly precipitation totals increase in the north and slightly in the east, while it decreases in the south and slightly in the west. The area of increase in the number of dry days covers almost all of Poland except the coast. This suggests that over a significant area, warming is associated with fewer days with precipitation but higher daily totals. In January and February, an increase in precipitation and the number of wet days is clearly visible, with a decrease in the number of dry days. This trend is usually attributed to the entire winter.

Among the three spring months, the most substantial changes are observed in April. Precipitation is decreasing in almost the entire country, significantly in the north and west. In the same regions, the number of dry days is increasing, and the number of wet days is decreasing, but with lower intensity, suggesting a decrease in the abundance of precipitation, expressed by the average total per day with precipitation. In March, there is an apparent increase in dry days and a decrease in the number of wet days, most strongly in the center and on the coast. At the same time, precipitation totals are lower only on the coast and in the center, which is also likely due to changes in precipitation abundance. In May, no change in rainfall pattern is observed.

During the summer, precipitation decreases in the south and increases in the north. A similar picture characterizes changes in the frequency of dry and wet days. Such a north–south gradient of rainfall trends (wetter on the north/drier on the south) in the midlatitudes in Europe has been discussed by many authors [39,44]. In Poland, it is observed only in summer.

Changes in the autumn months are also quite varied. September is drier in the north of the country, with more rainfall in the south. The number of wet days decreases significantly in the north and remains virtually unchanged in the south. In contrast, dry days increase throughout the country, but most strongly in the north. Such an arrangement should also be associated with a change in rainfall abundance. In October, changes are relatively small. A slight increase in precipitation is observed in the south and west, as well as in the area of the Gulf of Gdansk at the mouth of the Vistula River. Consistent with this trend, changes occur in the frequencies of dry and wet days. Very strong changes are recorded in November everywhere, except in the southeastern parts of Poland. Precipitation decreases and the number of dry days increases accordingly. Furthermore, wet days decrease and these changes are noted to be significant over a wide area. The turn of autumn and winter, November and December, until recently were symbols of gloomy rainy weather. They are now increasingly drier, with the weather becoming more typical of October. Rainy weather is observed more and more often in January. The above considerations suggest that an analysis of the changes in abundance of precipitation could yield interesting results.

There is a great disproportion between the persistence and extent of dry and wet spells. In the case of dry spells, seven days were assumed as the minimum duration and occurrence in at least 12 stations, i.e., over 25% of the country area. Dry spells covered 5601 days, i.e., 96.5 on average per year and over 26% of all days. If the same condition were adopted in the definition of the wet spell, it would be possible to distinguish only a few of them, covering a total of 65 days, i.e., on average, just over one per year. Therefore, the requirements were reduced to 5 days and nine stations (20% of the country area). Despite this, only 1236 days were included in the wet spells, i.e., 21.3 on average per year and less than 6% of all days. This result confirms that dry spells are related to the presence of high-pressure systems over Poland, the persistence and spatial extent of which are usually longer than the duration of cyclonic weather [26]. The only significant long-term trend in a series of different characteristics of dry and wet spells concerns the duration of the longest dry spell in the year. This result is consistent with the suggested increase in high-pressure system persistence in Central Europe [45].

Preliminary analysis of the impact of atmospheric circulation on the occurrence of dry and wet spells indicates high seasonal variability. In the cold season, the Scandinavian type has the greatest influence; the presence of a high-pressure system over Scandinavia favors dry weather. In summer, precipitation and dry and wet spell occurrence are influenced by the NAO, AO, type EA, and the presence of a high-pressure system over Greenland. The influence of the EA/WR pattern can be noticed in spring and autumn. However, this issue requires more detailed analysis.

Funding: This research was funded by the National Science Center (NCN), grant number 2019/33/B/ST10/01136.

Data Availability Statement: The Polish meteorological data were taken from IMWM-NRI. The Greenland Blocking Index was taken from https://psl.noaa.gov/gcos_wgsp/Timeseries/Data/gbi.mon.data (accessed on 13 April 2024). The Atlantic Multidecadal Oscillation index was taken from https://www1.ncdc.noaa.gov/pub/data/cmb/ersst/v5/index/ersst.v5.amo.dat (accessed on 13 April 2023); remaining indices were taken from https://ftp.cpc.ncep.noaa.gov/wd52dg/data/indices/tele_index.nh (accessed on 13 April 2024).

Acknowledgments: The author would like to thank four anonymous reviewers for their valuable comments and Joanna Jędruszkiewicz for the help in linguistic proofreading.

Conflicts of Interest: The author declares no conflicts of interest.

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