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VARIABILITY OF THE MERIDIONAL CIRCULATION INDEX OVER POLAND ACCORDING TO THE LITYŃSKI CLASSIFICATION FORMULA

Zmienność wskaźnika cyrkulacji południkowej nad Polską według formuły Lityńskiego

Streszczenie. Na podstawie dobowych wartości ciśnienia atmosferycznego SLP (źródło: NCEP/NCAR) obliczono codzienne wartości współczynnika cyrkulacji południkowej (MCI) według wzoru zastosowanego przez Lityńskiego (1969, 1971, 1973). Brano pod uwagę gridy na południkach 0° i 35°E w zakresie od 40° do 65° N z krokiem co 2,5°. Analiza objęła okres 1948–2010. Średnie z tych 63 lat cechują się wyraźnym rytmem rocznym. Dodatnie średnie wartości MCI osiągane są od połowy września do połowy kwietnia, z maksimum między 8 a 12 listopada. Informują one o przewadze cyrkulacji południowej nad północną. Ujemne średnie wartości MCI występują od połowy maja do początku września. W wieloletnim przebiegu MCI nie wykryto trendów, ani w analizie średnich z poszczególnych „pełnych" lat, ani w analizie średnich z poszczególnych pór roku. Zmienność MCI z roku na rok była największa zimą (odchylenie standardowe $\sigma = 1{,}11$), a najmniejsza latem ($\sigma = 0{,}35$).

Słowa kluczowe: reanaliza, przebieg roczny, fluktuacja, filtr dolno-przepustowy, pory roku
Key words: reanalysis, annual course, long-term variation, low-pass filter, seasons

INTRODUCTION

The meridional circulation, beside the zonal circulation, realizes the important role in the formation of weather conditions in Poland. The inflow of the air from the northern sector can lead to the fall of the air temperature, meanwhile from the south to its growth.

The classification created by Lityński (1969, 1971, 1973) is one from the applied typologies of the atmospheric circulation over Poland. Three indices are considered in the Lityński's classification. They are zonal index, meridional index as well as pressure index. The calendar of every days types has been published for the period 1951–1999 (Stępniewska-Podrażka 1991, Pawłowska et al. 2000). The remarks about the Lityński classification of the atmospheric circulation types has been presented during the conference "Advances in weather and circulation type classifications & applications" (Nowosad 2008a) and the conclusions has been published (Nowosad 2008b).

The aim of the work is the characteristic of variability of one of circulation indices (MCI) applied by Lityński (1969, 1971, 1973) to his circulation types classification. The variability of this index in the annual cycle is investigated as well as the long-term variation of MCI is investigated too.

MATERIAL AND METHODS

Daily values of see level pressure (SLP) from NCEP/NCAR reanalysis from the meridians 0° and 35°E (with 2.5 degree step) between 40° and 65°N are the data for this study. The reanalysis data are available online for the period from 1948 to nowadays. The data from 1948 to 2010 has been analysed in this paper. On the other hand SLP for the period 1900–1966 (from the meridians 0° and 35°E between 40° and 65°N) has been the source material to MCI calculation by Lityński (1969). This author determined SLP using the lower synoptic maps. MCI for the each day has been calculated with the formula:

$$MCI = 10\ (P35 - P0)/35$$

where:
MCI – meridional circulation index ($m \cdot s^{-1}$),
P35 – mean air pressure on meridian 35°E (between 40–65°N),
P0 – mean air pressure on meridian 0°E (between 40–65°N).

It is the same formula as proposed by Lityński (1969). MCI is defined as the speed of geostrophic wind.

The positive MCI value informs about the dominance of the circulation from south. The negative MCI value is connected with the dominance of the circulation from north. The daily values of MCI since 1st Jan. 1948 till 31st Dec. 2010 has been considered in this paper.

The annual course of MCI has been smoothed by low-pass filter for daily data proposed by von Storch and Zwiers (1999, p. 388)[1].

The circulation types hasn't been created in this paper. It seems that applying the value of the indices is useful to synoptic climatology investigations instead of the circulation types. Publishing the only concrete type is the considerable decrease of accessible information. One can create some classes of MCI using the calendar[2].

ANNUAL COURSE OF MCI

The mean annual value of MCI for the whole period of 1948–2010 is equal to +0.4 $m \cdot s^{-1}$. It informs about the little dominance of southern circulation over northern one in the whole year scale. The southern circulation dominance over the northern circulation is visible in the winter (mean MCI +1.0 $m \cdot s^{-1}$), in the autumn (+0.9 $m \cdot s^{-1}$) as well as in the spring (+0.3 $m \cdot s^{-1}$). On the other hand, the northern circulation dominance over the southern one take place in the summer (mean MCI minus 0.8 $m \cdot s^{-1}$). The annual course of the mean value of MCI is presented on fig. 1. There is presented the smooth course (after using the filter proposed by von Storch and Zwiers 1999) too. Lityński (1969) wrote that the advantage of the southern circulation over northern one is visible in the winter, meanwhile northern component prevails over southern one in the summer.

This feature is presented exactly on fig. 1. The prevalence of the southern circulation over northern one (positive values of MCI) appears on average from the middle of September to the middle of the April. The highest mean values of MCI, exceeding 2 $m \cdot s^{-1}$, took place from 8th to 12th November. Negative mean values of MCI (the domination of northern circulation over southern one) has been found between the middle of May and the beginning of September. The systematic increase of MCI take place from the beginning of July to the November maximum.

The highest and the lowest daily MCI appear between 28th November and 21st February. The highest daily MCI are: +12.8 $m \cdot s^{-1}$ (5th Feb. 1951), +12.3 $m \cdot s^{-1}$ (28th Nov. 1954) and +11.9 $m \cdot s^{-1}$ (1st Jan. 1949). The lowest ones: minus 9.7 $m \cdot s^{-1}$ (31st Jan. 1949), minus 9.4 $m \cdot s^{-1}$ (21st Feb. 1959) and minus 9.0 $m \cdot s^{-1}$ (30th Dec. 1974).

[1] The symmetric filter is defined as follows: $f(a_0) = -0.01518a_{-9} - 0.03003a_{-8} - 0.03684a_{-7} - 0.02820a_{-6} + 0.04625a_{-4} + 0.10288a_{-3} + 0.15769a_{-2} + 0.19744a_{-1} + 0.21196a_0 + 0.19744a_1 + 0.15769a_2 + 0.10288a_3 + 0.04625a_4 - 0.02820a_6 - 0.03684a_7 - 0.03003a_8 - 0.01518a_9$

[2] The MCI calendar is available in the internet http://serwisy.umcs.lublin.pl/marek.nowosad/tercile

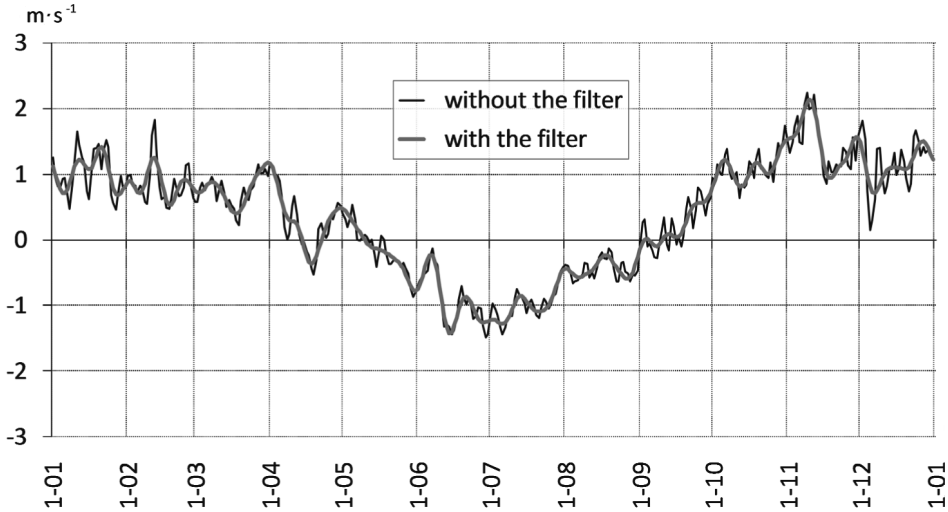

Fig. 1. The mean MCI values for each day during the year for 1948–2010 period. Low-pass filter for daily data proposed by von Storch and Zwiers has been applied (see text)
Ryc. 1. Średnie wartości wskaźnika cyrkulacji południkowej (MCI) dla każdego dnia cyklu rocznego (1948–2010). Zastosowano filtr dolnoprzepustowy proponowany przez von Storcha i Zwiersa dla danych dobowych (zob. tekst)

LONG-TERM VARIATION OF MCI

The long-term fluctuations of mean MCI values for the whole year as well as for the seasons (spring, summer, autumn and winter) has been shown on fig. 2, 3 and 4. Trend detections gives the negative results. The trends hasn't been found for the 63 years period.

The standard deviation (σ) of 63 values[3] (each value represents each year) informs us about interannual variability of MCI. The interannual variability of MCI is high in winter (σ = 1.11) and in autumn (σ = 0.89) as well as low in summer (σ = 0.35). Standard deviation for the whole year is equal to 0.38 and for spring 0.59. The interannual variability of MCI for the whole year is higher in the period 1948–1985 (σ = 0.44) than in the period 1985–2010 (σ = 0.25) – see fig. 2.

The highest mean annual MCI took place in 1951 (+1.5 $m \cdot s^{-1}$) and in 1960 (+1.2 $m \cdot s^{-1}$). The negative MCI values represent years: 1955, 1964, 1971, 1973, 1975, 1983, 1997 and 2007 (Fig. 2). This negative values show the dominance of northern circulation over southern one. The highest northern dominance took place in 1973 (mean annual MCI = minus 0.5 $m \cdot s^{-1}$).

[3] The standard deviation (σ) of 62 values has been calculated for winter season.

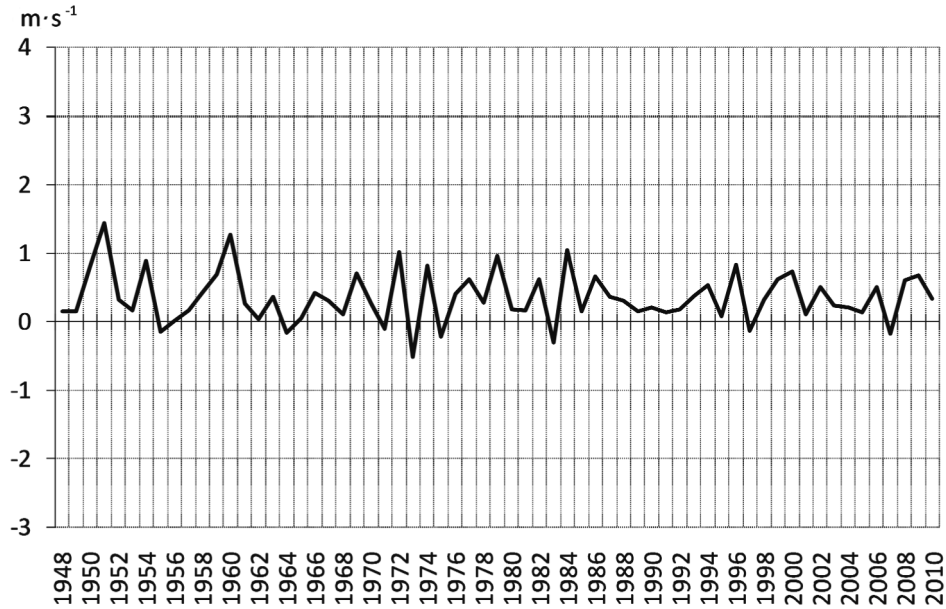

Fig. 2. The mean annual MCI values (1948–2010)
Ryc. 2. Średnie roczne wartości wskaźnika cyrkulacji południkowej MCI (1948–2010)

The seasonal spring MCI values reach values between +1.9 $m \cdot s^{-1}$ (1986) and minus 1.4 $m \cdot s^{-1}$ (1997).

The seasonal MCI for each of 63 summer seasons has been negative (fig. 3). The lowest values took place in 1949 and 1976 (minus 1.7 $m \cdot s^{-1}$) and in 1984 (minus 1.5 $m \cdot s^{-1}$). During these summer seasons the dominance of northern circulation over southern one has been the biggest. The situation attracts the attention, that the index of the northern circulation calculated by Filipiuk and Kaszewski (2010) reach in 1984 the highest summer value for the period 1881–2009. The highest summer seasonal MCI took place in 1951 (minus 0.1 ms^{-1}) and in 1992 (minus 0.2 $m \cdot s^{-1}$). The summer dominance of northern circulation has been lowest in 1951 and 1992.

One can underline very high values of autumn seasonal MCI in 2000 (+3.8 $m \cdot s^{-1}$). The negative autumn seasonal MCI values took place during three neighbour years: 1971, 1972 and 1973 (Fig. 3).

Fig. 4 shows high interannual variability of winter MCI. The highest winter seasonal MCI values appear in winter 1950/1951 (+3.8 $m \cdot s^{-1}$) and 1968/1969 (+3.0 $m \cdot s^{-1}$), 1959/1960 and 1976/1977 (+2.9 $m \cdot s^{-1}$). The lowest one took place in the winter 1991/1992 (minus 2.0 $m \cdot s^{-1}$).

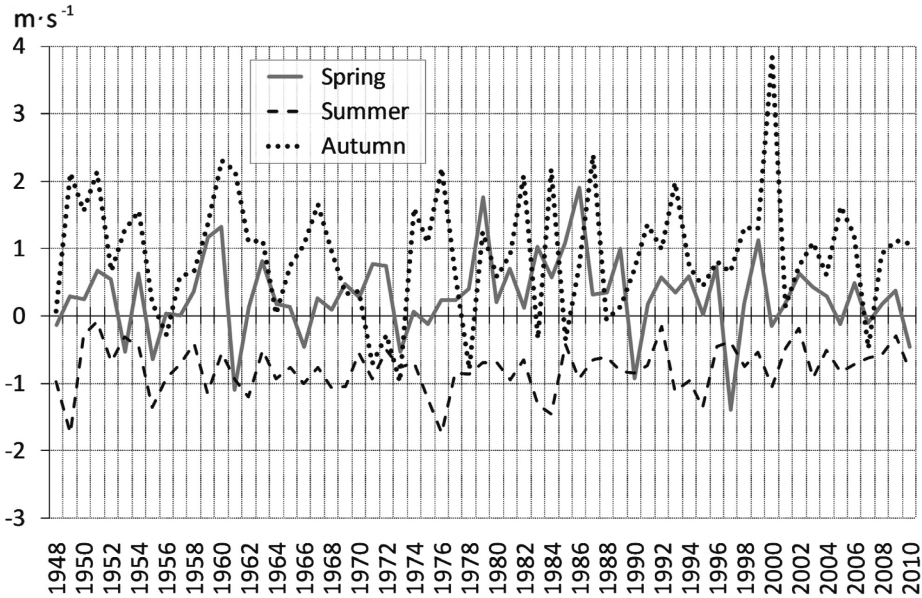

Fig. 3. The mean seasonal MCI values (1948–2010) – spring, summer, autumn
Ryc. 3. Średnie sezonowe wartości wskaźnika cyrkulacji południkowej MCI (1948–2010) – wiosna, lato, jesień

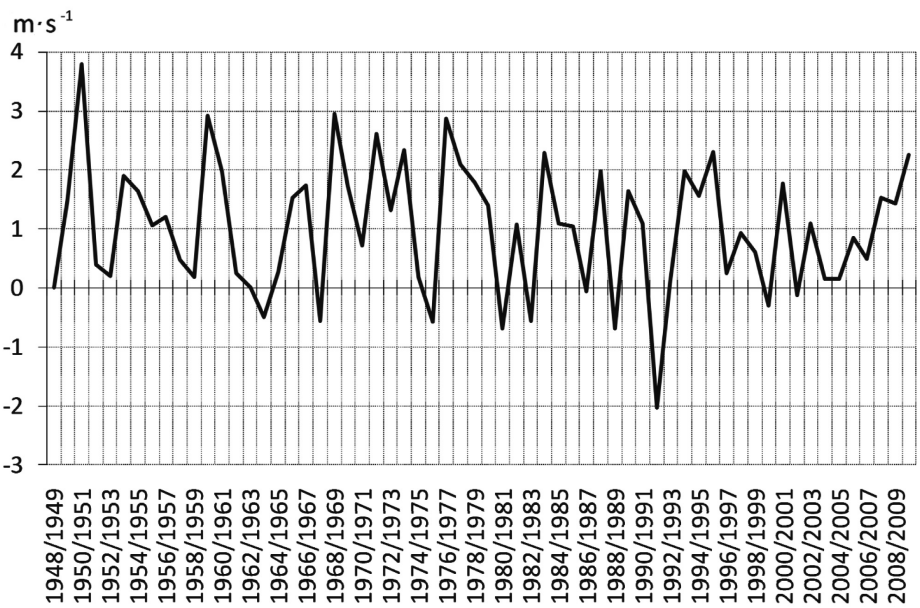

Fig. 4. The mean seasonal MCI values (1948/1949–2009/2010) – winter
Ryc. 4. Średnie sezonowe wartości wskaźnika cyrkulacji południkowej MCI (1948/49–2009/10 – zima

CONCLUSIONS

The Meridional Circulation Index is characterized by the clear seasonal rhythm. Positive average values MCI are achieved from the half of September to the half of the April with the maximum between 8 and 12 November. Negative average values MCI appear from the half of May to the beginning of September.

The interannual variability of MCI is high in winter (σ = 1.11) and low in summer (σ = 0.35). The highest and the lowest daily MCI took place in winter.

The significant linear trend of increase or decrease of MCI in the period 1948–2010 was not found. It concerns to the whole year as well as to each of four seasons (spring, summer, autumn, winter).

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