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# DIURNAL VARIATIONS OF ATMOSPHERIC PRESSURE IN SIEDLCE IN 2001–2022

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## ABSTRACT

**Aim of the study**
Rising and falling atmospheric pressure usually heralds changes in weather conditions such as temperature, air humidity, cloud cover, precipitation, and wind speed. The work presents variations of atmospheric pressure in Siedlce from 2001 to 2022. The objective of the present work is to analyse diurnal variations in atmospheric pressure, as well as the amplitude of fluctuations and trends.

**Materials and methods**
Daily atmospheric pressure values were obtained from a meteorological station of the Institute of Meteorology and Water Management (IMGW). Diurnal changes in atmospheric pressure causing different levels of strain on the human body, ranging from weak to very strong, were identified. For each month, the number of days with specific diurnal pressure changes was calculated. The trend in monthly pressure changes was determined based on linear regression equations.

**Results and conclusions**
The average annual atmospheric pressure at sea level in Siedlce was 1016 hPa, the lowest and the highest recorded pressure values being, respectively, 928 hPa on 25th March, 2016, and 1051 hPa on 23rd January 2006. The difference between the highest and the lowest pressure values in a given month was the greatest in January and February (40 hPa), and the lowest in August (17 hPa). The summer months of July and August, classified as weak stimulus days, exhibited the greatest diurnal variation in atmospheric pressure, while December and January were classified as very strong stimulus days, because they showed the highest variation. Monthly atmospheric pressure values in Siedlce displayed no substantial tendency to change during the study period.

**Keywords:** atmospheric pressure, annual pattern, diurnal variation, tendency to change, Siedlce

## INTRODUCTION

It is frequently emphasised that meteorological elements have a significant impact on the onset and intensity of illness-related complaints. This association has been confirmed in long-term clinical observations. Rising and falling atmospheric pressure usually heralds changes in weather conditions such as temperature, air humidity, cloud cover, precipitation, and wind speed (Koźmiński and Michalska, 2012). Vari-

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ation in weather types may cause diverse disruptions in everyday lives of susceptible individuals, such as exacerbation of chronic diseases, migraines, increased incidence of depression, worsening of gastric ulcer symptoms (Timmermans et al., 2014; Tamasauskiene et al., 2017; Lee et al., 2018). However, weather and its changeability are not the primary causes of diseases; they can only trigger reactions in sensitive parts of the body (Wanka et al., 2014).

The underlying mechanisms affecting health and wellbeing are complex, and they frequently depend on multiple variables. One of such variables is atmospheric pressure, which, together with wind parameters, falls under the category of biometeorological mechanical stimuli. The exact mechanisms of physiological reactions occurring in the human body resulting from the influence of atmospheric pressure and its fluctuations are not yet fully understood (Błażejczyk, 2004). The effect of pressure on the human body mainly occurs through the nervous system, and depends on the intensity of the stimulus. The stimulating effect is primarily associated with short-term fluctuations in atmospheric pressure (Kozłowska-Szczęsna et al., 1997) as well as with pressure values that are significantly higher or lower than average. The most adverse stimuli are substantial diurnal fluctuations in atmospheric pressure. The work by Kuchcik (1999) contains analysis of the impact of weather conditions on mortality in Warsaw's residents. The analysis revealed an occurrence of respiratory system insufficiency on days with high atmospheric pressure and during diurnal pressure drops of at least 15 hPa. According to Błażejczyk (2004), the rise and fall of atmospheric pressure is followed by the expansion and compression of air in the middle ear, resulting in deformation of the eardrum and sensations of pressure, piercing, ringing in the ears, and even temporary hearing impairment. By contrast, Baranowski et al. (1998) claim that substantial fluctuations in atmospheric pressure can lead to disorders of the heart and circulatory system function. In their 50-day monitoring study of a 48-year-old patient conducted in Kiev, also Delyukov et al. (2001) demonstrated variations in the electrocardiogram (ECG) pattern due to an impact of atmospheric pressure changes. Rapid changes in atmospheric pressure can cause mood swings, anxiety and nervousness (Kozłowska-Szczęsna et al., 1997). Authors of numerous studies (Moshkowitz et al., 1994; Gonzales et al., 2001; Nomura et al., 2001; Manfredini et al., 2010) also indicate the season-related occurrence of peptic ulcer complications that is an increase in the frequency of such complications during early spring and autumn. The body's response to high pressure includes a smoother course of physiological processes, deeper breathing, increased lung capacity, slower heart rate, and a decrease in the number of red blood cells and haemoglobin in the blood (Papiernik, 2004; Błażejczyk et al., 2014). Research on the impact of meteorological factors on traffic accidents, carried out since the 1940s in Germany and since the 1970s in Poland, has revealed that response times lengthen and the psycho-physical efficiency of drivers decreases during cyclonic weather phases (Wojtach, 2002). In developed, urbanised societies, there are more instances of abnormal and unexpected patterns of response displayed by the body due to civilisation-related changes in lifestyle, which weaken adaptive abilities and health. Anthropogenic climate change is predominantly related to the creation of increasingly comfortable living conditions for humans in industrialized countries, and production driven by a consumerist lifestyle (Gulla et al., 2020). Projections of future climate change point to the need to re-examine the relationships between weather and medical conditions. Better understanding of the connections between climate variations as a determinant of diseases will be of importance in constructing models for public prophylactic healthcare management. The consequences of climate change will differ depending on the region and the existing susceptibility of the population (Patz et al., 2000; Szyga-Pluta and Półrolniczak, 2012).

The objective of the present work is to analyse the diurnal variation in atmospheric pressure, as well as the amplitude of fluctuations and trends thereof in Siedlce in 2001–2022.

## MATERIALS AND METHODS

In the present work, we used average daily atmospheric pressure values for the years 2001–2022, obtained from the IMGW meteorological station located in Siedlce (φ° = 52 ° 11', λ° = 22 °16', H = 146 m a.s.l.).

According to Kondracki (1994), the study area includes the Mazowsze-Podlasie Lowlands classified as sub-provinces of Central Polish Lowlands. The region's mesoclimate displays variation due to features of the terrain. Continental characteristics are increasingly strong in the easterly direction, them being associated with the length of the winter period and temperatures during the winter months. The continental features of the local climate include the lowest temperatures of winter months while summer temperatures are similar to values in the west of the country. The average amplitude of air temperature can be as high as 23°C. Average annual precipitation totals fluctuate around 550 mm, and the snow cover remains for 80–100 days.

The paper presents daily pressure values averaged over the analysed long-term period, and the monthly average, minimum, and maximum pressure values. The fluctuations of and the variations in the examined parameter are presented using the amplitude and coefficient of variation (R). Both Błażejczyk (2004) and Kozłowska-Szczęsna et al. (2004) assume atmospheric pressure changes of > 8 hPa to be uncomfortable for the human body, whereas according to Rozbicka and Rozbicki (2016) such values include ≤ 4 hPa (weak changes) and >12 hPa (very strong changes). An intermediate classification was adopted in the study, and changes in atmospheric pressure considered uncomfortable for the human body were defined as changes exceeding 6 hPa. Diurnal fluctuations of atmospheric pressure were classified as follows:

- up to 6.0 hPa – weak strain on the body,
- 6.1–12.0 hPa – moderate strain on the body,
- 12.1–20.0 hPa – severe strain on the body,
- 20.1 hPa and more – very severe strain on the body.

For each month, the number of days with specific diurnal pressure changes was calculated. Moreover, the trend of changes in average monthly atmospheric pressure values was also presented.

## RESULTS AND DISCUSSIONS

The average annual atmospheric pressure at sea level in Siedlce from 2001 to 2022 was 1016 hPa, consistent with the value presented in the Atlas of Poland's Climate (1991–2020) (Tomczyk and Bednorz, 2022) (Table 1). The average long-term daily pressure values were the lowest in late January and early February (Fig. 1). In contrast, the highest values of this parameter were recorded in mid-February and mid-November. Monthly pressure values were lowest in July (1013 hPa), assuming the highest values in October (1018 hPa) (Table 1). Over the study period, the lowest and the highest pressure was re-

**Table 1.** Average monthly atmospheric pressure values, minimum and maximum values, and coefficients of variability (V)

| Parameters | Jan | Feb | March | April | May | June | July | Aug | Sep | Oct | Nov | Dec | Annual average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average [hPa] | 1016 | 1016 | 1015 | 1015 | 1015 | 1014 | 1013 | 1015 | 1017 | 1018 | 1017 | 1017 | 1016 |
| Max [hPa] | 1051 | 1045 | 1046 | 1035 | 1031 | 1028 | 1029 | 1030 | 1036 | 1040 | 1041 | 1045 | 1023 |
| Min [hPa] | 984 | 979 | 928 | 992 | 997 | 997 | 994 | 999 | 997 | 983 | 987 | 982 | 1009 |
| Amplitude [hPa] | 40 | 40 | 38 | 27 | 21 | 19 | 18 | 17 | 25 | 29 | 33 | 39 | 29 |
| V [%] | 0.47 | 0.46 | 0.50 | 0.29 | 0.26 | 0.19 | 0.22 | 0.25 | 0.21 | 0.36 | 0.48 | 0.46 | 0.35 |

Source: own study

corded, respectively, in March (928 hPa) and in January (1051 hPa). Atmospheric pressure stimulus effects occur when pressure values are higher than 1015 hPa, or lower than 985 hPa (Błażejczyk, 2002; Nawrocka and Szyga-Pluta, 2018). In Siedlce, the difference between the highest and the lowest pressure values in a given month was the highest in January and February (40 hPa), and the lowest in August (17 hPa). Matuszko (2007) reports that the differences between the highest and the lowest average values during winter months in Kraków are more than twice as large compared to the respective differences in summer months.

The summer months of July and August, classified as weakly stimulating in Siedlce, are characterised by the highest diurnal variation in atmospheric pressure (Fig. 2). Nearly all the days (28 days) of the two months exhibited weak stimulation. In the warm season of the year, this variation is much smaller than in the cold season, which is typical of moderate latitudes (Kozłowska-Szczęsna et al., 1997; Fortuniak et al., 2000).

Moderate strain on the body caused by diurnal variation in atmospheric pressure was observed in January (9 days) as well as February, March, and December (8 days). There were fewer months with severe strain on the body (12.1–20.0 hPa) than those with very severe strain – the latter occurred only in January, February, and December, averaging 0.5 days per month. The months with days characterised by very severe strain on the body due to diurnal variation in pressure were January, February, March, October, November, and December. Of these, December had the greatest number of such days (averaging over 1 day). In the study period, there were 27, 13, 7, 4 and 4 such days, respectively, in December, January, February, March and November, and only one such day was observed in October. Similar results were also reported by Półrolniczak (2010) for Poznań. This author noted that annual patterns of the frequency of days with no perception or weak perception of variation in pressure are cyclical in character, which manifests itself with the least occurrence in the colder part of the year and the highest in the warmer part. Koźmiński and Michalska (2010 and 2012) claim that, in Poland, marked diurnal variation in atmospheric pressure is mainly associated with the movement of deep pressure lows which are the most frequent in winter.

Analysis of the trend of changes in average monthly pressure values in Siedlce showed very little variation (Fig. 3). The trend gradients for all months were small. Only in November and December trend variation was observed: increasing in November (an increase of 4.4 hPa/10 years), and decreasing in October (2.3 hPa/10 years).

## CONCLUSIONS

1. The average annual atmospheric pressure in Siedlce over the period of 2001–2022 was 1016 hPa. The lowest value (928 hPa) was recorded on 25th March, 2016, and the highest (1051 hPa) on 23rd January, 2006.
2. The amplitude of fluctuations in atmospheric pressure ranged from 17 hPa in August to 40 hPa in January and February.
3. July and August were the months with the highest number of days characterised by weak strain on the body due to diurnal pressure variation, while December and January had the most days with very severe strain on the body.
4. Monthly values of atmospheric pressure in Siedlce displayed no substantial tendency to change. The highest trend gradients were obtained for November (positive) and December (negative).

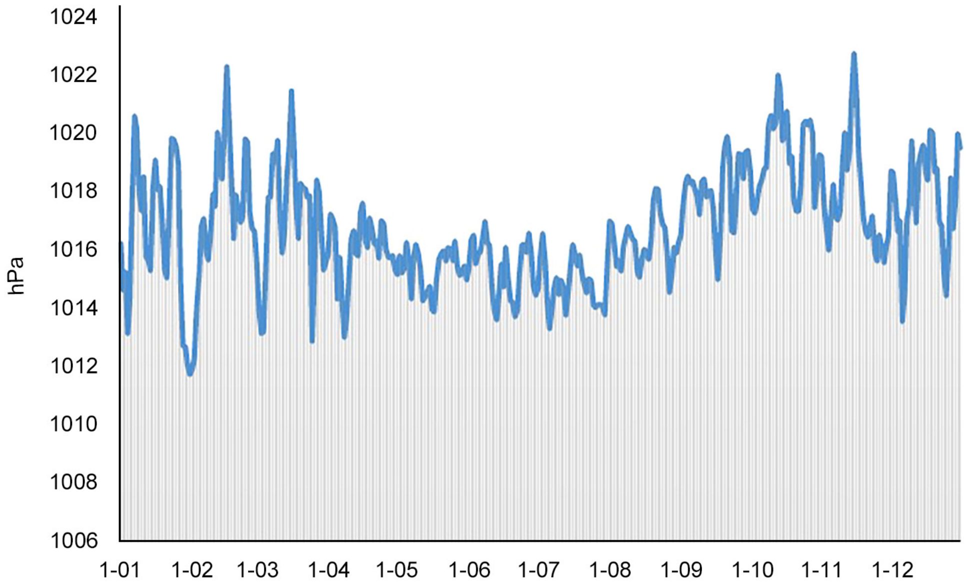


**Fig. 1.** The pattern of atmospheric pressure daily values in Siedlce averaged over 2001–2022

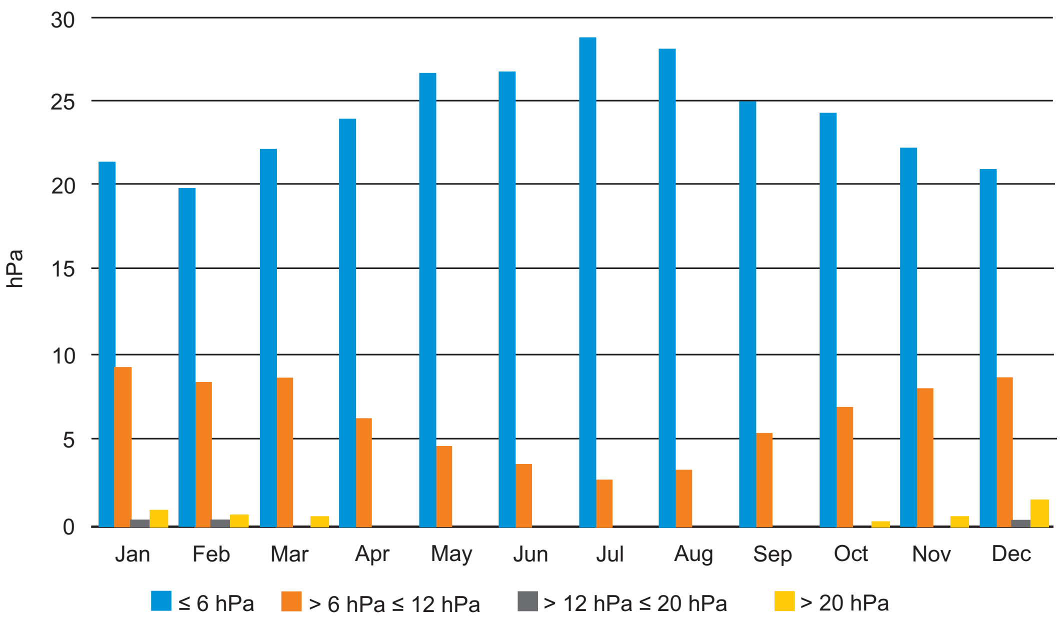


**Fig. 2.** Number of days with diurnal variation of atmospheric pressure in individual ranges

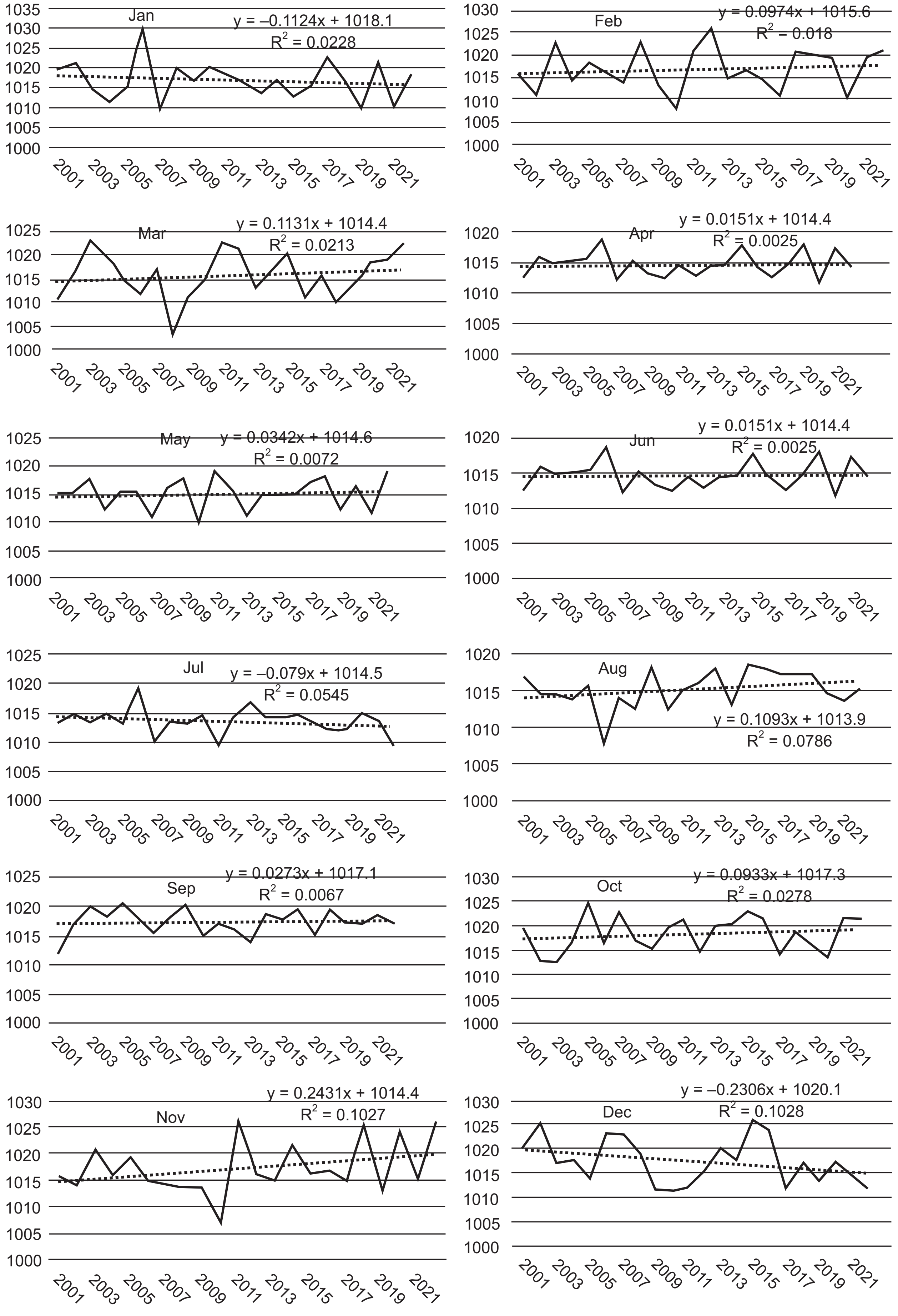


**Fig. 3.** Linear trends of changes in average monthly atmospheric pressure values in Siedlce in 2001–2022 and their coefficients of determination ($R^2$)

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## DOBOWE ZMIANY CIŚNIENIA ATMOSFERYCZNEGO W SIEDLCACH W LATACH 2001–2022

### ABSTRAKT

**Cel pracy**
Wzrost i spadek ciśnienia atmosferycznego zwykle zwiastuje zmiany warunków pogodowych, takich jak temperatura, wilgotność powietrza, zachmurzenie, opady atmosferyczne i prędkość wiatru. W pracy przedstawiono zmienność ciśnienia atmosferycznego w Siedlcach w latach 2001–2022. Celem pracy jest analiza dobowych zmian ciśnienia atmosferycznego oraz amplitudy wahań i trendów.

**Materiały i metody**
Dobowe wartości ciśnienia atmosferycznego uzyskano ze stacji meteorologicznej Instytutu Meteorologii i Gospodarki Wodnej (IMGW). Zidentyfikowano dobowe zmiany ciśnienia atmosferycznego powodujące różne poziomy obciążenia organizmu człowieka, od słabego do bardzo silnego. Dla każdego miesiąca obliczono liczbę dni z określonymi dobowymi zmianami ciśnienia. Trend miesięcznych zmian ciśnienia wyznaczono na podstawie równań regresji liniowej.

**Wyniki i wnioski**
Średnie roczne ciśnienie atmosferyczne na poziomie morza w Siedlcach wynosiło 1016 hPa, przy czym najniższa i najwyższa zarejestrowana wartość ciśnienia wyniosły odpowiednio 928 hPa w dniu 25 marca 2016 r. i 1051 hPa w dniu 23 stycznia 2006 r. Różnica między najwyższą i najniższą wartością ciśnienia w danym miesiącu największa była w styczniu i lutym (40 hPa), najniższa w sierpniu (17 hPa). Miesiące letnie lipiec i sierpień, sklasyfikowane jako słabo bodźcowe, charakteryzowały się największą dobową zmiennością ciśnienia atmosferycznego, natomiast grudzień i styczeń, które były dniami bardzo silnie bodźcowymi, charakteryzowały się największą zmiennością. Miesięczne wartości ciśnienia atmosferycznego w Siedlcach nie wykazywały istotnej tendencji do zmian w okresie badań.

**Słowa kluczowe:** ciśnienie atmosferyczne, schemat roczny, zmienność dobowa, tendencja zmian, Siedlce