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AIR PRESSURE EXTREMES DURING THE INSTRUMENTAL OBSERVATION PERIOD IN WARSAW

Abstract: The study is based on the recently collected air pressure series originated from the Astronomical Observatory in Warsaw for the period 1826-1999. Analysis was performed in few steps concerning annual, monthly and daily pressure extremes. Special attention was paid to the 24 hour changes which have significant environmental and human aspects. Day-to-day differences over ± 15 and ± 20 hPa have been considered in more detail. Finally, the circulation causes of the high pressure changes are being analysed against the background of *Grosswetterlagen*.

Key words: air pressure, daily values, extremes, pressure variability.

1. Introduction

Air pressure belongs to particularly important climatic elements. It is not only the climatic element but also the one which plays the crucial role in circulation formation. From that point of view pressure can be treated as the climatic factor, and the study of its variability could be helpful in the diagnostics of climate change. Its importance has been recognised long time ago, hence the air pressure measurements belong to the first instrumental meteorological observations. On the other hand, that element plays a significant environmental and physiological role. Its extreme values can cause different repercussions and it especially concerns the living beings. Thus, the analysis of both long-term variability as well as its short-term (day-to-day) changes seems to be very important.

The literature concerning long-term pressure studies contains many important works, however the analyses based on the daily resolution data are quite unique. Only recently the situation has been changed (Trepińska 1988, 1997; Bärring et al. 1999).

The main objective of the study is the indication of different extreme pressure values on the basis of the entire series. Attention is also paid to the detection of any tendencies in pressure extremes.

2. Materials and Method

The study is based on the air pressure measurements originated from the Astronomical Observatory in Warsaw in the period 1826-1999. Detailed history of the station, metadata and some technical and merit remarks can be found in literature (e.g. Gorczyński 1917; Rojecki 1968; Lipska-Płaczek 1989). The data contain values from 3-4 observational terms which were the basis for the mean daily and monthly values. Due to some small gaps and inhomogeneities in the series from Astronomical Observatory (e.g. in the 70s of 19th century, during the Second World War) data from some other stations located in Warsaw had been used. Because of that and in order to provide comparisons with other European stations, all pressure values were reduced to the sea level. Homogeneity of the data - its monthly values - was checked with the use of Alexandersson test. It was not possible with the daily data, where only formal control was performed. In the cases where some doubts appeared, very precise analysis with the help of the Cracow series was provided. The simple standard statistical methods have been applied.

3. Annual and Monthly Values

At the beginning, the general review of the annual and mean monthly values has been done. During the entire observational period a slight increasing tendency of the mean annual value is being observed. There is no regular or quasi regular variability of air pressure. During some periods its values were higher (e.g. 1880-1910, at the beginning of 70s and on the turn of 80s and 90s of the 20th century). All these periods have been interrupted by short periods with lower pressure. The lowest values oscillating around 1014 hPa can be seen in the middle of the 19th century. It must be stressed, that only in the 19th century annual pressure values were falling to the level below the mean sea level value i.e. 1013.3 hPa. For example, in 1836 the mean value reached 1012.9 hPa which is the absolute minimum of annual pressure in the whole series. Simultaneously, the highest pressure was calculated for the year 1920 (1019.4 hPa); values over 1018 hPa have also occurred in 1929, 1953 and 1972 and only once in the 19th century (1932).

Obviously, the annual values result from the monthly means. Also their variability is strongly associated with changes of the monthly values, especially in winter season. During that season, the largest deviations can be observed which is well expressed by the standard deviation values, exceeding 5 hPa for December, January and February and reaching only 2.1-2.2 hPa in summer. Thus, in Figure 1 mean January pressure changes are presented. It can be seen, that rather high variability of air pressure can be observed during the whole period and no constant trend can be noticed. The highest value occurred in 1864 (1029.9 hPa), the lowest in 1915 (1004.7 hPa). The

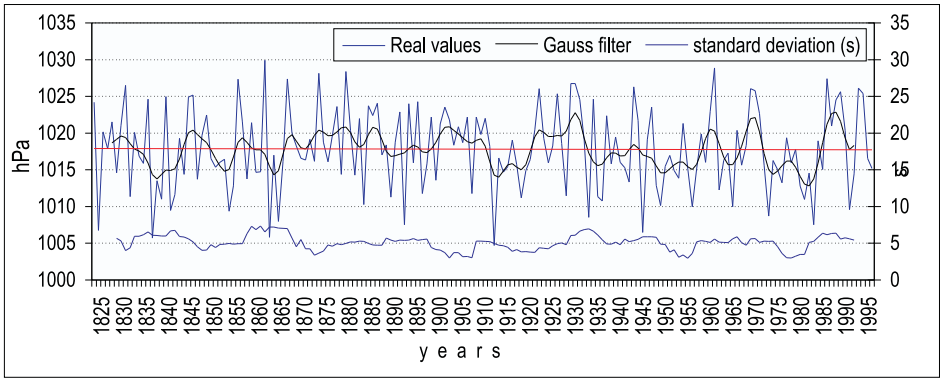

Fig. 1. Mean January atmospheric pressure and its standard deviations in Warsaw.

curve of the standard deviation indicates that the largest variability of January mean values from year to year is observed in the 60s of the 19th century and in the middle of 30s of the 20th century. The last period with relatively high standard deviations can be seen in the second part of 80s.

4. Daily Extreme Values

As it was stated in the introductory part, the main attention was paid to the daily extremes. The maximum and minimum annual values from the second observation term are presented in Figure 2. It confirms that there are no significant changes in the entire period. Very low values which occurred during the recent decades could be recognised as such changes. The absolute minimum pressure dropped to 972.1 hPa and took place on 3 December 1976. The second lowest value occurred on 26 February 1989 (972.8 hPa). During 21 days the air pressure dropped below 980.0 hPa. Simultaneously, the absolute maximum pressure was observed on 23 January 1907 and reached 1061.8 (!). That value is unusually high in the Central Europe and is rather adequate to the values occurring in the Asian anticyclone. The situation was checked at the synoptic map and was also compared with the measurements from Cracow. It is worth pointing out that the second high value reached 'only' 1054.0 on 9 January 1929. In the entire investigated period, 11 cases with pressure over 1050.0 hPa have been observed.

In the next step, the maximum, minimum and average daily values have been taken under consideration from the yearly perspective (Fig. 3). This also confirms the dependencies obtained in the previous analysis. It means that the lowest variability during a year is seen at the average values. Of course, the highest values of extremes can be noticed in cold season, the lowest in summer. Thus, the absolute pressure amplitude is in winter and can reach for the particular day up to 78.3 hPa (on 3rd December). Much smaller values occur since the end of March due to the maximum values, which reveal a distinct fall during that time.

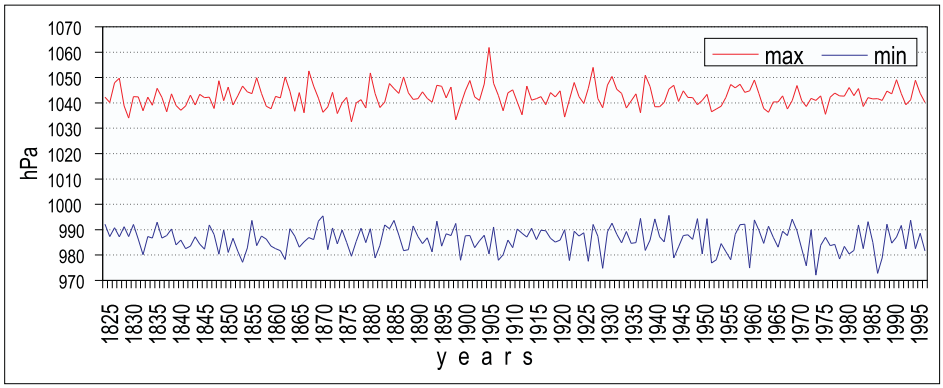

Fig. 2. Maximum and minimum annual values of the atmospheric pressure in Warsaw.

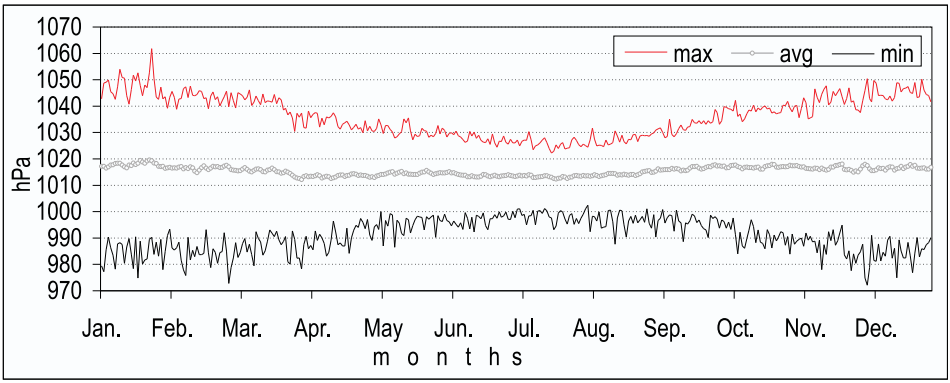

Fig. 3. Absolute maximum, absolute minimum and average daily pressure values for particular day of the year in Warsaw (1826-1999).

5. Daily Pressure Changes

From the environmental and physiological point of view, the most interesting are changes of air pressure from day to day. It was not possible to apply the regular pressure tendency in the synoptic meaning, i.e. the pressure changes during 3 hours, in the study. We decided to calculate the 24-hour changes with the use of the second observational term. As shows Figure 4, the maximum 24-hour changes can reach in Warsaw ±40 hPa, which is a very high value. Both cases mentioned above occurred in the first few years of the 20th century. The highest increase, 39.5 hPa, was observed on 7/8 January 1905, the lowest -40.6 on 15/16 January 1902. Of course, very high changes over ±30 hPa are rarely noted. In the entire series only 14 increases and 9 decreases exceeding 30 hPa in 24 hours have been observed. It must be stressed that

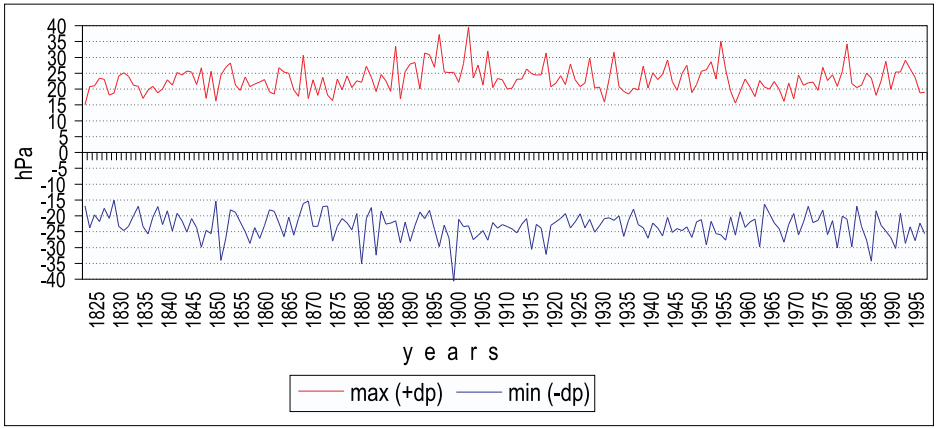

Fig. 4. Annual maximum of the 24-hour pressure changes (±) in Warsaw (the second observational term).

values over ±20 hPa in 24 hours are usually being considered as very high pressure changes. Such cases happen few times in a year (exactly 2.8), but there are some years without such changes and years with 9 events (1850, 1867, 1981; Fig. 5). The highest number took place in 1995 when 10 changes over ±20 hPa have been measured.

Finally, the introductory analysis of the 24 hours pressure changes have been performed against the background of the circulation types. Due to the length of available circulation calendar and the spatial size, *Grosswetterlagen* (Gerstengarbe, Werner 1993) has been applied. As showns Figure 6 the highest negative changes happen during Wz and NWz situation (i.e. with the W and NW advection cyclonic type). During these types almost 100 cases with decrease below 20 hPa had taken place. During the same situations smaller increases over the same value of 20 hPa

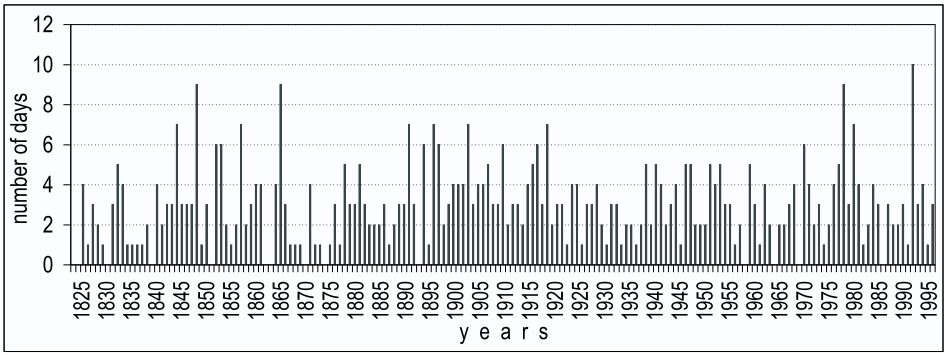

Fig. 5. 24-hour pressure changes over ±20 hPa in Warsaw (the second observational term).

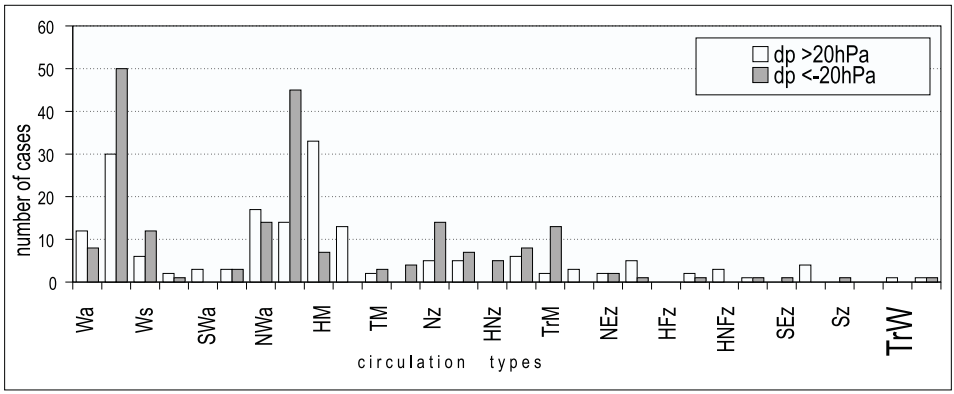

Fig. 6. Pressure 24-hours changes over ±20 hPa in Warsaw at the particular circulation types of Grosswetterlagen.

were noted. Most of them was measured at HM type (anticyclone over the Central Europe; totally over 30 cases). For other types, much smaller number of both cases was observed. Very similar structure is seen for pressure change over ±15 hPa. Thus, it confirms that the highest day-to-day pressure changes can happen mainly during cyclonic situation with the westerly and northwesterly advection. It was shown also for Cracow with the application of another circulation types' calendar (Falarz 1997). They are associated with the cyclone tracks, usually with the front systems. Also, the positive changes exceeding 15 or 20 hPa are quite frequent during the development of high pressure centre over Central Europe.

6. Conclusions

The study provides an introductory analysis of the Warsaw pressure extremes based on daily values reduced to the sea level from the period 1826-1999. The mean annual values reveal a slightly increasing trend while most months do not result with such symptoms. It also concerns winter season when both the absolute highest and lowest values can be observed. The absolute maximum registered pressure value (in the second observational term) reached 1061.8 hPa (23 January 1907), the absolute minimum fell to 972.8 hPa (on 26 February 1989). The maximum 24 hours changes in Warsaw reached ±40 hPa what seems a very high value. The highest increase of 39.5 hPa was observed on 7/8 January 1905, the lowest -40.6 on 15/16 January 1902. In the entire series, only 25 cases exceeding ±30 hPa in 24 hours have been observed. The pressure changes over ± 20 hPa in 24 hours occur usually few times a year but there are some years without such changes and years with 9 or even 10 events. Application of circulation types reveals that the highest day-to-day pressure changes can occur mainly during cyclonic situation with the westerly and northwesterly advection. Positive changes exceeding 15 or 20 hPa are also associated with high over

Central Europe. Taking into account the different extreme pressure measurements and long-term analysis, no significant trends can not be easily seen.

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