ASSESSMENT OF DROUGHT IN LANDSCAPE

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Abstract: *In the article is shown the procedure of calculation PDSI out of precipitation data, temperature and data of potential evapotraspiration, to show the application of monthly values from Observatory in Prague – Klementinum to calculating Palmer Drought Severity Index (PDSI) for the period 1805 – 2000 (196 years) and it's evaluation from the point of view of time trends and occurrence of drought periods during the selected time.*
It indicates that the conditions of both spots are not much different to conditions of the region in USA for which PDSI was implied. The fact that the index was used for the first time in 1965 and is employed till now should suggest that its construction is so sophisticated to be worthy for applying it also by us.
Key words: *natural precipitation, temperature, evapotranspiration, and drought, Palmer Drought Severity Index*

1. Introduction

Evaluation of Drought and drought its frequent theme of climatologic works especially in semiarid areas. They often come in touch with dryness and with caused economical damages, which often gain serious extent. In temporary Middle Europe climate it is the top theme of interest of specialists and public mostly after occurrence of drought and short after just till the next flood. In spite of that we think that even in this conditions it is necessary to engage in systematic research and work out due methods which can enable to signalise the start of dry period and quick estimation of its importance in separate regions.

The seek to achieve objectives of this article is to show the application of monthly values of temperature and precipitation from Observatory in Prague – Klementinum to calculating Palmer Drought Severity Index (PDSI) for the period 1805 – 2000 (196 years) and it's evaluation from the point of view of time trends and occurrence of drought periods during the selected time.

Klementinum - Meteorological observatory in Prague is the working place, which gave the oldest continually saved measurements of basic meteorological elements in the area of Middle Europe. The regular and certain measurements of precipitation are available from 1st May 1804. Some decennaries after were entered measurements of precipitation in Jena (1827), Dresden (1828), Budapest and in Vienna (1841), in Berlin (1847) etc. (PEJML 1975). Systematic temperature range is available even from 1775. It is apparent that the mentioned well-knit time range is suitable footing for numerable executions especially dealing with oscillation of meteorological elements for more than 200 years period for the region of Middle Europe.

2. Material and Methods

One of more used methods for drought evaluation especially in USA is Palmer Drought Severity Index (PDSI). It was originally estimated for USA but we know from recent times some works describing its application in Middle European conditions (BRIFFA, K.R. 1994, HORVATH S., KLEMENTOVA E., LITSCHMANN T., 2001). Describe of the construction and calculation

PDSI is apparent from work for instance (ALLEY, M.W. 1984). The Palmer Drought Severity Index was constructed by Palmer estimating criteria in such a way that especially rainy month between dry period does not influence too much the value of index. Similar it is when there is a term of nearly normal precipitation following after dry period, which does not mean that drought has finished.

Palmer´s index regards climatic characteristics of the region as well as its basic soil hydrolimits. It means that the same value of Palmer´s index in various regions should have nearly the same economical impact. Its value varies in latitude from – 6 to + 6. According to our experience, it can range also apart from those limits in singular extreme cases. In Table 1 are shown the intervals of values related to the worldly expressions representing precipitate character of the period.

We succeeded in obtaining the FORTRAN source program for calculating PDSI monthly values from USA. We can now shape it according to our needs especially in entering data and the outcomes as well as we can change empirical coefficients and follow the impacts of the change to the result value PDSI. By studying the source code we can better understand the global philosophy of the calculation and use of separate equations. As entering data we used monthly values of temperature and temperature from the station Prague-Klementinum for the period 1805 – 2000. Thornthwait Method implemented direct in the program using the corresponding indexes related to the followed station calculated potential evapotranspiration.

Tab. 1   Labelling the values PDSI

Palmer Classifications			
4.0 or more	Extremely wet	**0.49 to -0.49**	Near normal
3.0 to 3.99	Very wet	**-0.5 to -0.99**	Incipient dry spell
2.0 to 2.99	Moderately wet	**-1.0 to -1.99**	Mild drought
1.0 to 1.99	Slightly wet	**-2.0 to -2.99**	Moderate drought
0.5 to 0.99	Incipient wet spell	**-4.0 or less**	Extreme drought

3.   Results and Discussion

Monthly values PDSI are shown on Figure 1 for the whole processed period. On the background of the diagram can be seen the picture of allocation of thermometer and hygrometer in Klementinum Observatory.

It is apparent that it is not typical climatological station and that is why it is not possible to use the data coming out of it to the common time and place processing. Its value is in integrated time range measurements suitable for studying the oscillation of climate in recent centuries.

Palmer Drought Severity Index is constructed in such a way that when it is correctly calculated its values for the processed period are located nearly symmetrically to zero level. It means that in chosen locality are alternating dry and wet periods.

On Figure 2 is shown empirical distribution curve of values PDSI calculated for Klementinum and it is compared to distribution curve presented for USA. It is clear that those curves are very similar. It declares that constants used in our calculations enables to gain the results comparable to data computed in other parts of the world.
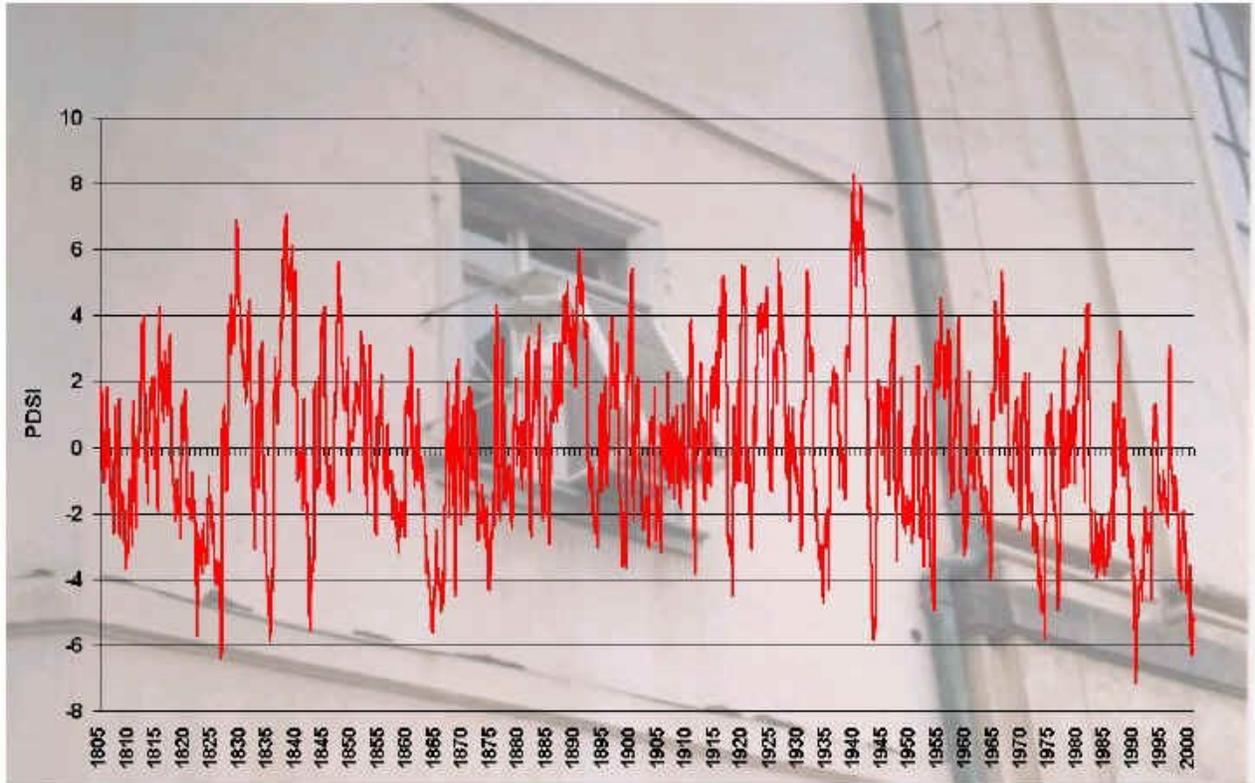
Fig. 1   Monthly values PDSI (Prague – Klementinum)
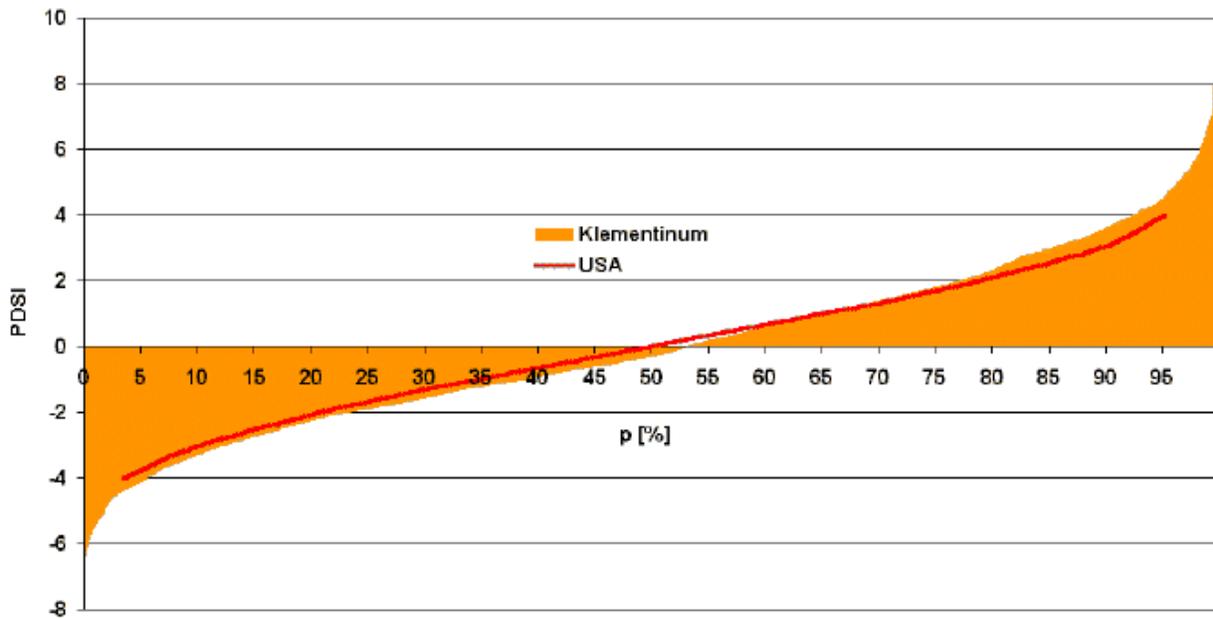

Fig. 2 Distribution curve of values PDSI for Klementinum (1805 – 2000)

From Fig. 1 is apparent that in last 196 years were varying periods with overrunning tendency to more dryness with periods more humid. That is why we decided to plot the number of month in which the value of PDSI has decline under – 2 in separate decennaries.

In Tab. 2 is chosen 10 months of the lowest values PDSI from the whole processed period. The year 1990 holds four places and the rest are divided to 2000 and 1826 three times each. The warning fact is that the last 11 years of processed period in the mentioned chart holds 7 places.

Tab. 2 Order of ten month with lowest values PDSI from 1805

Year	Month	PDSI	Year	Month	PDSI
1990	8	-7,15	**1926**	8	-6,20
1990	7	-6,76	**2000**	9	-6,15
1826	9	-6,39	**1826**	10	-6,09
1990	9	-6,37	**2000**	6	-6,09
2000	8	-6,31	**1990**	10	-5,94

Fig. 3 represents the result of the processing and is quite conclusive. It documents the presence of the months characterised as mild during last two decennaries and is showing increase of drought from 1811.

The situation is significant because the two decades followed consecutively and the number of the months classified in such a way in every decade overrun half of the total number. Greater number of dry months is evident already in 1971 – 1980 which followed after rather wet sixties which has interrupted for a while the general increase of dryness from the years of forties.
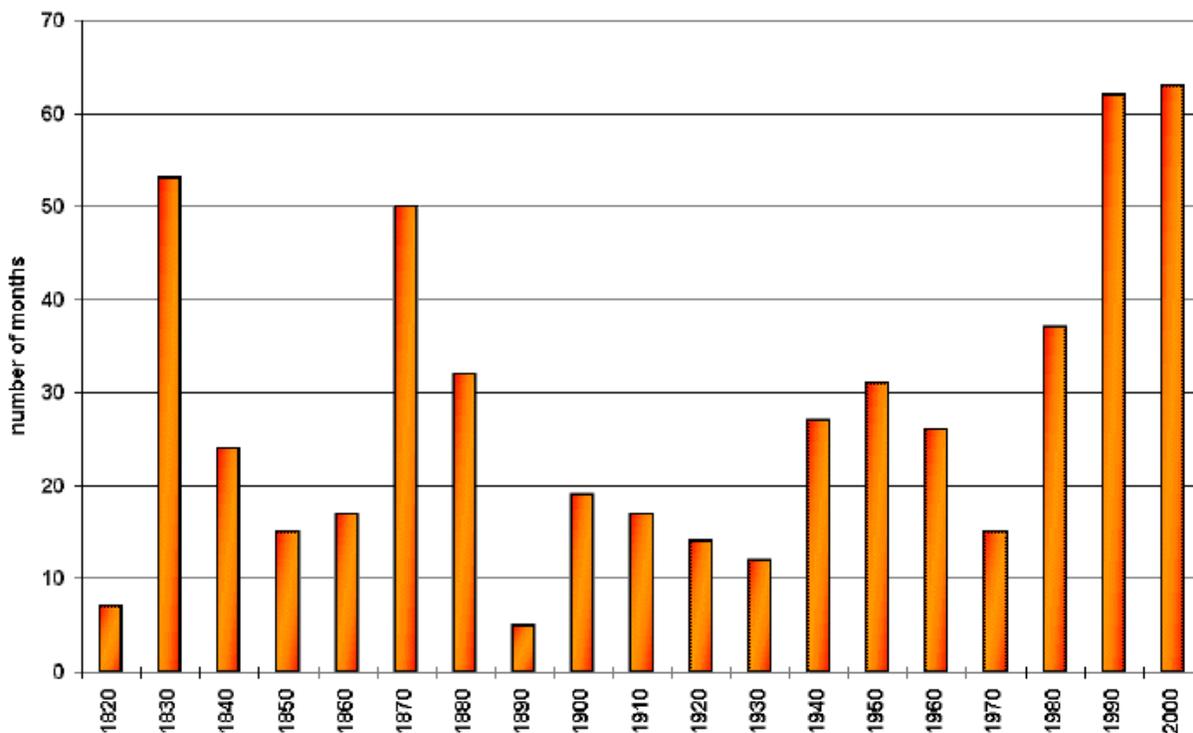

Fig. 3 Number of month with values PDSI under –2 in separate decennaries   (Prague – Klementinum)

If we can say that in curve of overrun values PDSI for the whole processed period should be applied that the parameters respond to certain standards and do not differ in separate localities Fig. 2 the same must not be said for two separate selections from the whole file. We have tried to divided the whole processed period to two parts. They are up to 1950 and from 1951 on.

The result is on Fig. 4. and shows the increase of presumption drought in categories mild drought and moderate drought (under – 2) nearly about 15%.

In category extreme drought (under – 4) it is about 5% compared to previous period. By K-S test we verified that the difference is significant on the level   0,05.

From Fig. 1 we can assume that dry and wet periods are repeating in certain intervals seemingly regularly. By a simple method, which is autocorrelation, it can be shown that the time range includes cyclic element, which has maximum in 111 month (9 and ¼ years) in its length.

As shows the Figure 5 the maximum is slightly beyond the limit of significance. It is related to low values PDSI in last decennaries, which appeared in 2000, 1990, 1984, 1974, 1964, 1954 and 1943 so nearly spacing related curve autocorelative function.
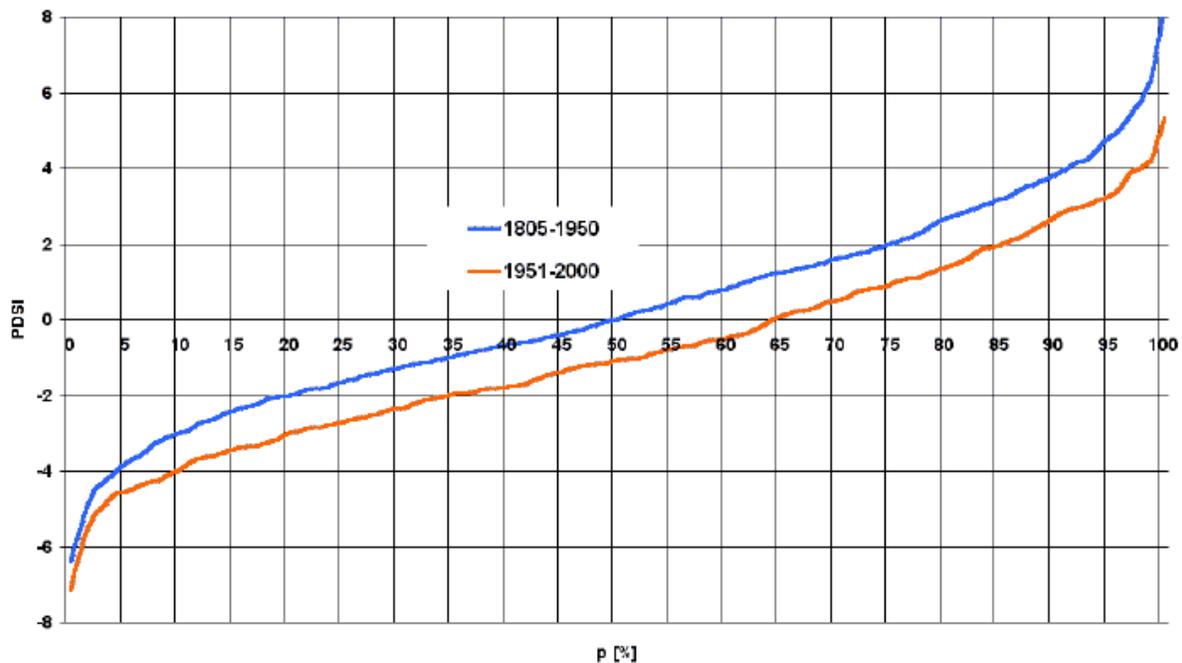

Fig. 4 Comparison of curves of overrun values PDSI for the period 1805 – 1950 and 1951 – 2000 (Prague – Klementinum)
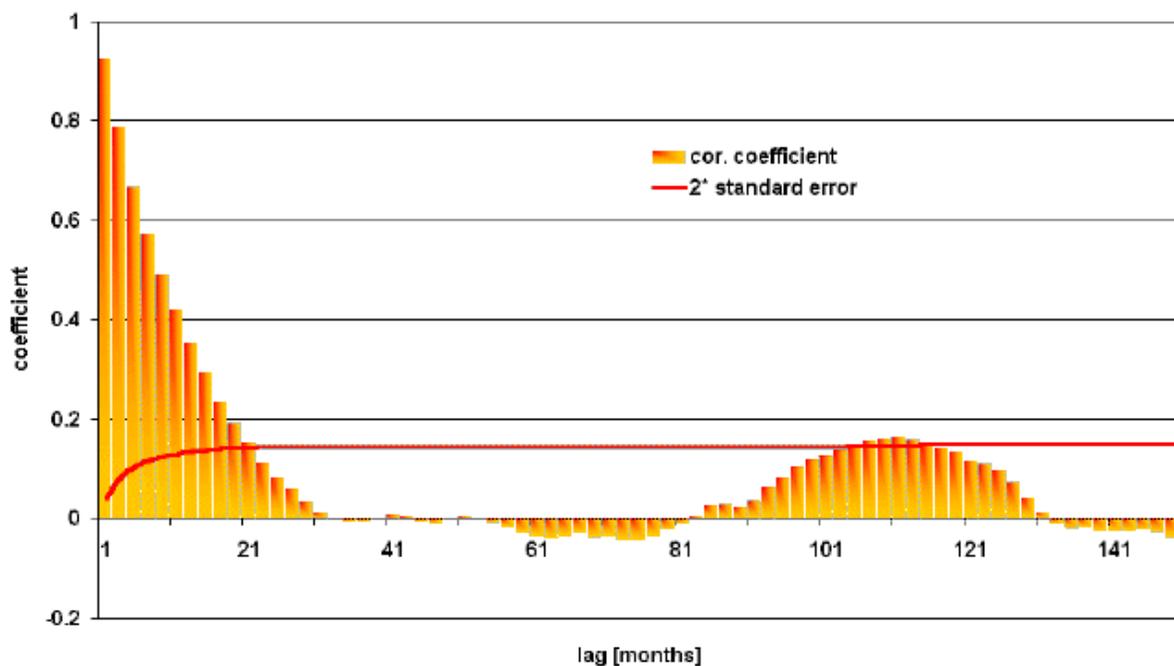
Fig. 5 Development of autocorelative indexes of monthly values PDSI (Prague – Klementinum, 1805 – 2000)

4. Summary

By application of calculations PDSI in Klementinum time range we succeeded to figure some facts related to drought in Middle Europe region:

- Frequency of dry months in last two or three decennaries gained maximum during the whole processed period. It is significant that the mentioned decennaries are consecutive.
- In last 50 years occurred increase about 15 % of the months classified as mild drought and extremely drought about 5 %.
- Seven of ten most dry months from the whole processed period occurred in last 11 years.
- The calculation of autocorelation showed that time range of values PDSI holds cyclic element lasting nearly 9 and ¼ years. The same periodicity corresponds with occurrence of dry periods in the second half of 20 century.

In area dislocation of rains we can see greater variability and in analysing Klementine time range is evident that more drought then in 2000 was about ten years earlier. In 1947 was dry but in 1943 and 1954 were values PDSI even more lowly. It probably was caused by the lack of objective method for evaluation of drought and it has signs of subjective approach. Political situation or interests of journalists can also influence the mentioned vision.

In evaluating tendencies and long-term trends of drought is necessary to use the longest time ranges. The length of one referenced period is for the mentioned evaluation inadequate.

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