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VARIOUS TYPES OF CHANGES IN CLIMATIC SERIES OF BUDAPEST AND SZEGED, COMPARISON WITH REMOTE CLIMATIC STATIONS

by
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Különböző típusú éghajlatingadozások a budapesti és szegedi adatsorokban összehasonlítás távoli klímaállomásokkal.
A viszonylag hoszabb éghajlati adatsorokban a rövidebb-hosszabb változások különböző formái jelenhetnek meg *(1. ábra)*. Budapest 150 éves, Szeged 137 éves csapadéksorozatában kimutatható egy emelkedő trend 1940-ig, majd 1941 után egy meredek süllyedő trend gyors nívóváltással. Másrészt 1841-től illetve 1854-től 1990-ig csökkenő változékonyság a jellemző. Hasonló emelkedő, majd süllyedő trend található Kiev és Barnaul csapadéksorozatában. Ezzel ellentétes változások jelentkeztek Kelet-USA illetve Kelet-Ausztrália területén. Budapest 200 éves hőmérsékleti sorozatában az 1880-as évekig süllyedő, innen emelkedő trend mutatkozik, ez utóbbi összehasonlítható a globális átlaghőmérséklet rendelkezésre álló sorozatával *(4. ábra)*.

In climatic series of relatively long period may appear shorter or longer changes of different forms *(Fig. 1.)*. In the 150 year long precipitation series of Budapest and 137 year long series of that in Szeged it was found an increasing trend until 1940, thereafter a sharp decrease with rapid change of level. On the other hand since 1841 in Budapest and since 1854 in Szeged up to 1990 decreasing variability could be pointed out. Similar uptrend, the sinking was found in series of annual sum of precipitation of Kiyev and Barnaul. In the same time contrary trends appeared in the regions of East U.S.A. and East Australia, respectively. In 200 year long temperature series of Budapest a cooling trend is presented up to 1880-s, after that a warming tendency was found. The latter is comparable with the available data of global mean temperature *(Fig. 4.)*.

For the sake of correct definition of climate change or variation and distinguishing between their terms, such designations, appeared in the literature like fluctuation, oscillation, variation, trend etc. With negligation of determing the temperal scales, orders of magnitude and time units of the changes, we restrict our investigation to the forms of changes. On the basis of the forms of changes, six main types may be distinguished (*Pfister*, 1988):

1. periodic change (in its ideal form this type is mostly theoretical one),
2. quasiperiodic change,
3. rapid change of level with sharp trend
4. slow trend (rising or sinking),
5. stationary trend,
6. increasing or decreasing variability *(Fig. 1.)*.

The basic aim of this investigation to present some kind of change forms mentioned above, on Hungarian climatic series. It is evident that more comprehensive analysis would be needed to prove the existence of types at all, and what forms are not existing in the available climatic series. However our goal has been to provide only a few samples of climate changes in series of annual sums of precipitation and annual mean temperatures. This paper does not include analysis of monthly or seasonal data.

In recent decades a growing demand of hydrologists was experienced on investigation of precipitation data observed during the period of recent decades. This interest has been arosed by gradual sinking of underground water-level, the more and more frequent droughts which may be explained either with decrease of annual precipitation or with human activity (exhausting of ground water reservoirs). For this reason, the series of annual precipitations were investigated frist of all. In Hungary longest continues series of precipitation possesses Budapest where the observation began in 1841, so there were available a 150 year long series (1841—1990). A similar long series of precipitation data is found in Szeged, started in 1854, though two short breaks occured before 1871, thus only 120 year long continous series are available from 1871 to 1990 (*Hajósy, Kakas* and *Kéri*, 1975, *Réthly*, 1947, Monthly Reports of the Hungarian Meteorological Service — Havijelentések, 1971—1990).

It has been made use of so called rank analysis, i.e. the annual sums of precipitation were orderd from smaller to greater values regardless their cronology. This method is widespread in meteorological researches, because it provides comfortable and informative aid for data survey. It is worthy to mention that in 150 year long period the driest year in Budapest was 1857, with rank number one and only 326 mm annual sum of precipitation, while in the wettest year, 1937, with rank number 150, the annual sum of precipitation was as much as 989 mm. The ratio of annual precipitation in the year of rank one and that in the year of rank 150 is approximately 1:3. In Szeged the driest year was also 1857 with 267 mm annual sum, but the most precipitation, 979 mm was measured in 1855. The ratio between these extremes is as much as 1:3,66. Merely these simple ratios may rather well characterize the variability of precipilation in climate of Hungary.

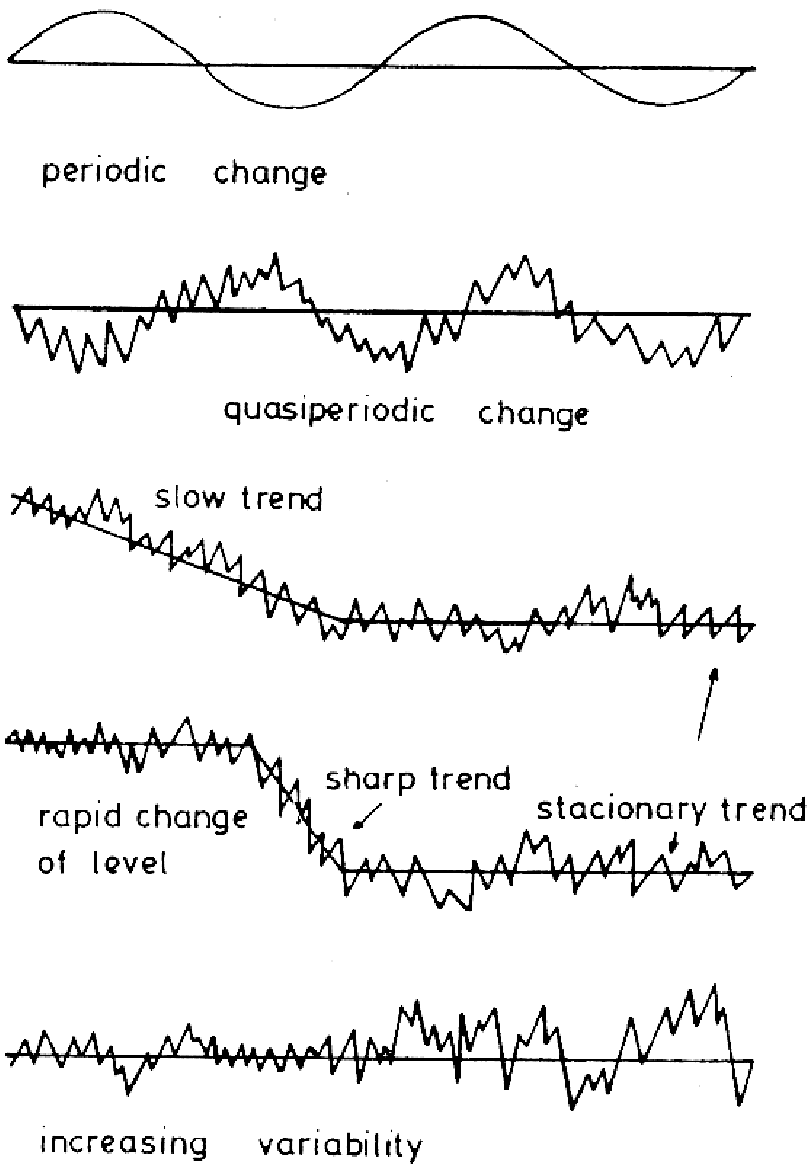

Fig. 1. Six types of climatic variations (after *Pfister*, 1988)

The series of annual sum of precipitation of Budapest were devided into three equally long periods: 1841—90, 1891—1940, and 1941—90, respectively. Each period is 50 year long. On the basis of rank number, 1—150, the data may be devided into terciles moereover even into deciles. In latter case it seemed sufficient only the lowest and highest deciles to be presented. The results are summerized in **Table I**. In the lowest three rows of the **Table I** the 50 year averages, the standard deviations, and the ratios of standard deviation/average, i.e. the relative standard deviations in per cent are given.

Table I
Statistical characteristics of annual precipitation of Budapest

	1841—90	1891—1940	1941—90	Total
Lower tercile (1—50)	16	12	22	50
Middle tercile (51—100)	17	17	16	50
Higher tercile (101—150)	17	21	12	50
Total	50	50	50	150
Lower decile (1—15)	6	2	7	15
Higher decile (136—150)	6	6	3	15
	Most variable	Wettest	Driest	
P (mm) std (mm) std/P %	617 130 21	639 110 17.2	574 107 18.6	

It can be clearly seen that in the first 50 year period between 1841 and 1890, the occurances of very dry and very wet years were practically equal, therefore this period is considered the *most variable.* For the second period, 1891—1940, the surplus of very wet years is characteristic, while the very dry years occured rarely. This period was *the wettest* comparing to others. The last 50 years (1941—90) possessed surplus of very dry years and deficit of wet years. This period was consequently the *driest one.*

From 1891—1940 to 1941—90 *in 50 year average precipitation* about 10% *decrease* occured which is *significant difference* at 1% significance level according to t-test. The standard deviation of annual sums *decreased* during the recent 150 years, but this decrease is a little less, than needed to 5% significance level.

The annual precipitation series of Szeged, as a control station were also discussed taking into consideration both the continuos 120 year series and the partly discontinuos 137 year period. The results are presented in **Table II**. It can be established that the 50 year period of 1891—90 was abundant in wet years, like in Budapest, while in period of 1941—90 in contrary, the surplus of very dry years followed. Just like in Budapest, also in Szeged a rapid sinking of level occured between 1930-s and 1940-s. The average precipitation of period 1891—1940 was 577 mm in Szeged, while in the next 50 year average took only 502 mm, the decrease amounted 13% from one period to the next. The *difference is significant* at 1% level. The standard deviation of annual sums was calculated for the discontinuos period, 1854—90, too, given in paranthesis in **Table II**.

Table II

Statistical characteristics of annual precipitation of Budapest

	1871—90	1891—1940	1941—90	Total
Lower tercile (1—40)	4	11	25	40
Middle tercile (41—80)	10	15	15	40
Higher tercile (81—120)	6	24	10	40
Total	20	50	50	120
Lower decile (1—12)	1	5	6	12
Higher decile (109—120)	1	9	2	12
	Most variable	Wettest	Driest	
P (mm) std (1854—90) std/P %	547 (525) 77 (133) 14 (25)	577 116 20.2	502 86 17	

According to F-test the *decrease of standard deviation is significant at 1% level.*

According to the analysis of decadal data it was pointed out that *rapid sinking of level* took place from the 1930-s to 1940-s, as it is shown in *Fig. 2.*, and above in *Fig. 3.* The former present the graph of variation of decadal precipitation in Budapest. The latter serves for comparison of long term variation of decadal precipitation in several remote climatic stations (after *H.H.Lamb*, 1977), including the graphs of Budapest and Szeged. It can be established the rough similarity at stations: Budapest, Szeged, Kiyev, Barnaul, the last with a lag of about ten years. Apparent contrasted trends exhibit the series of East U.S.A. and East Australia, namely relative wet periods were observed in these regions before 1890 or 1900, and after 1940 or 1950, while the same time in Budapest, Szeged, Kiyev and Barnaul were relative dry epochs, and reverse was the case in the first half of the 20-th century.

It is well know that in the 200 year long temperature series of Budapest (1781—1980) there appeared a sinking trend till the end of 19-th century, then it was followed by a rising tendency (*Fig. 4.*, above). The latter was interrupted by a transitory cooling by the 1960-s. Howerer a remarkable similarity can be found between the variations of smoothed global mean temperature (*Fig. 4.*, below) after *Lockwood*, 1986, *Barry* and *Chorley*, 1982, available since 1880. In general there is a rather good relationship between the length of averaging meteorological data and the size of area represented by the average.

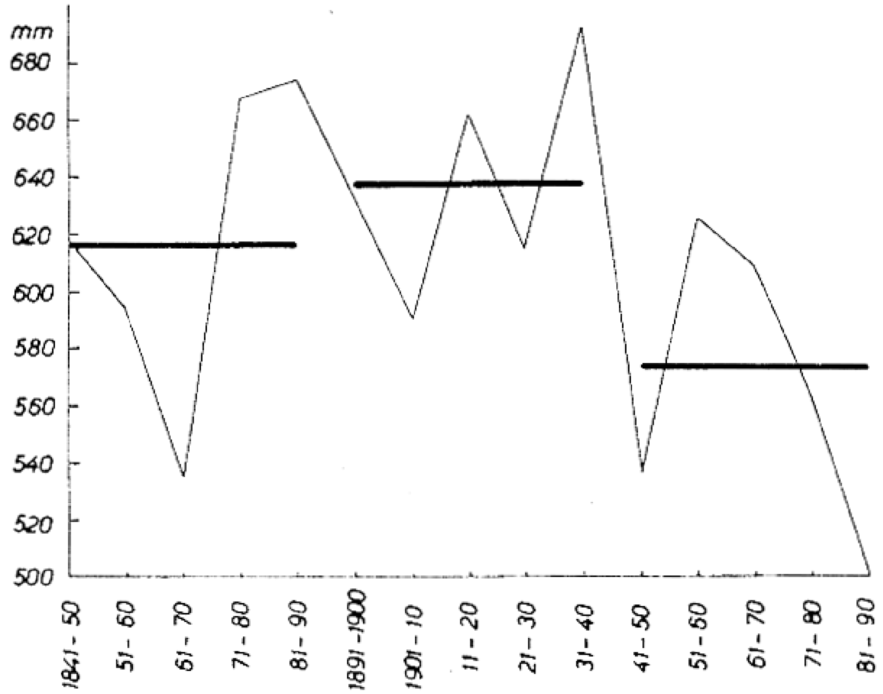

Fig. 2. Variation of decadal precipitation of Budapest during the period of 1841—1990 (thin line), and the 50 year averages: 1841—90, 1891—1940, 1941—90 (thick line)

In a previous paper (*Koppány,* 1992) it was pointed out that in 16 European and 2 North-American climatic stations, possessing more then 200 year long series of temperature data, exhibited more or less significant cooling in the second half of the 19-th century, mostly in 1880-s. Before that cooling in several stations remarkable warming was observed, some of them exceeding the maxima of 1930-s or 1940-s. The 9 year running mean of the temperature of these stations exhibited their maxima during the 18-th century or early 19-th century. After all it may be suggested that in several remote regions of the world after a relative warm period of the 18-th century (or the first half of the 19-th century) a sinking trend took place ended in 1880-s in long term temperature series.

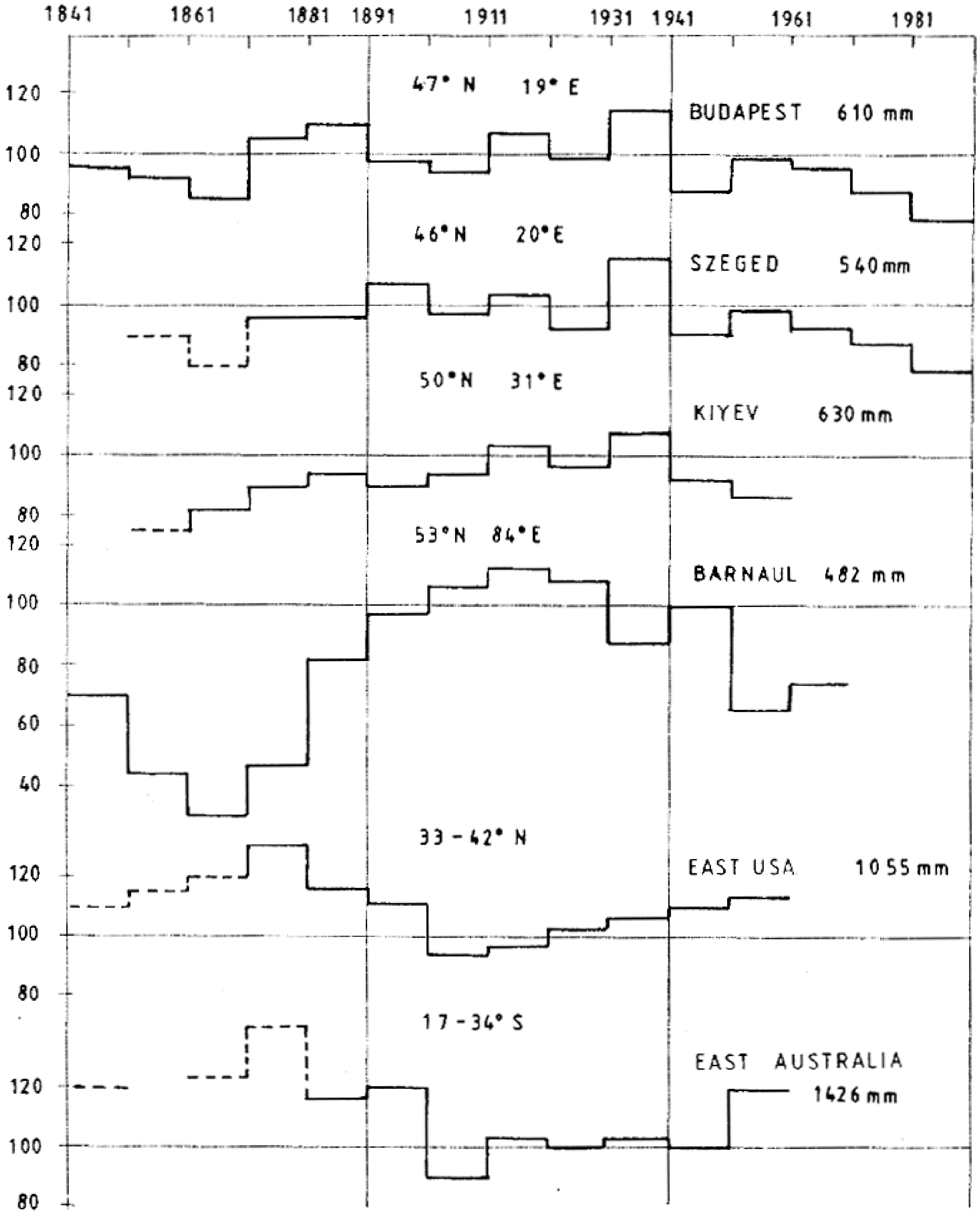

Fig. 3. Series of decadal precipitation of Budapest and Szeged, furthermore that of some remote climatic stations (the latter after *H.H. Lamb*, 1977)

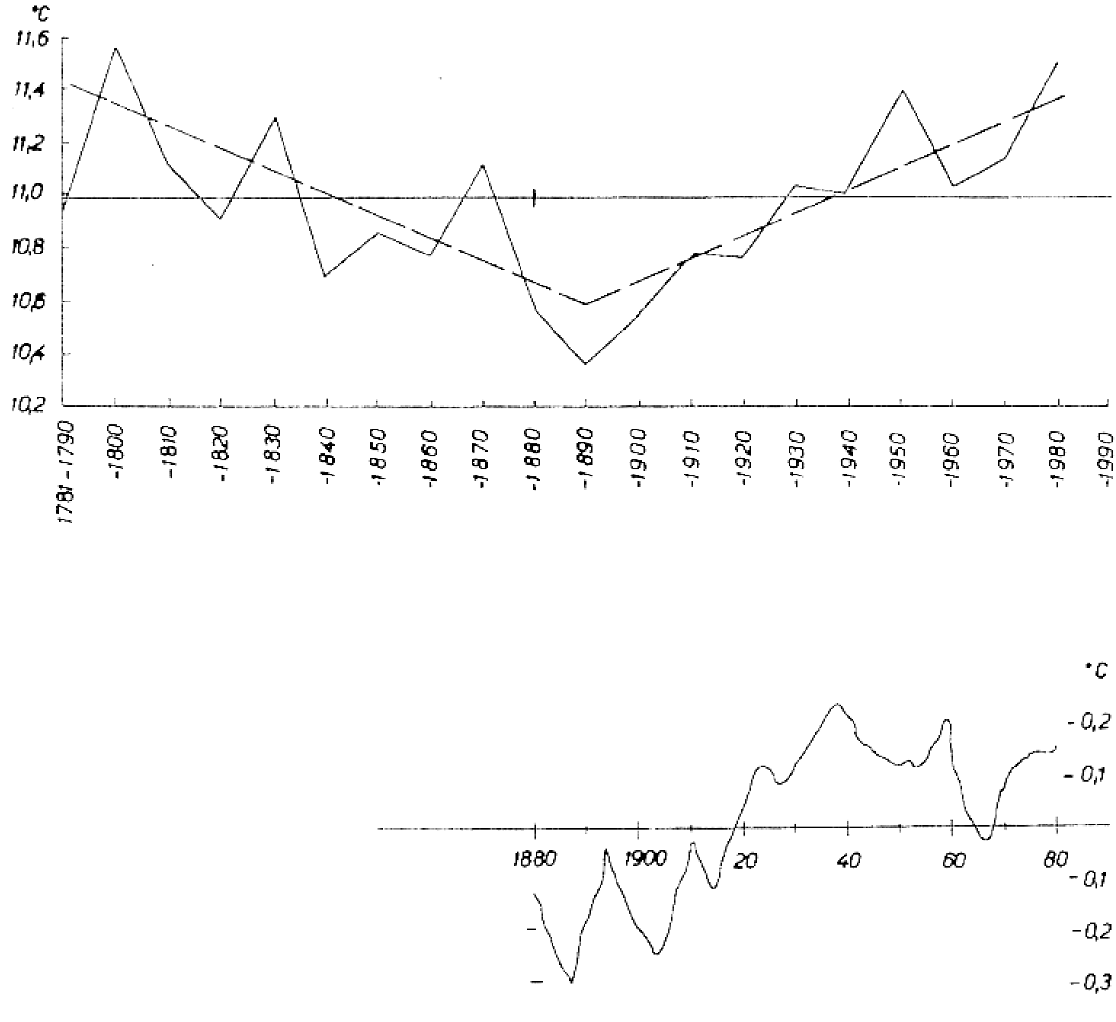

Fig. 4. Long term variation of decadal temperature of Budapest during the period of 1781—1980 (above), and variation of 5 year smoothed global mean temperature since 1880

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