PRACE GEOGRAFICZNE, zeszyt 107

Instytut Geografii UJ
Kraków 2000

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CLIMATE CHANGES DURING THE 20TH CENTURY IN HUNGARY

Abstract: This paper analyses trends and fluctuations in Hungarian temperature and precipitation data series. 98-year long data series of 14 observing stations are used. Statistical significance of systematic changes are controlled by t-probe and Mann-Kendall test. While changes in mean temperatures are small, notable decrease can be recognised in precipitation amounts particularly in transitional seasons, and in the second half of the century in winter. Changes in frequencies of extreme daily mean temperatures are also investigated. Amplitudes of their long term fluctuations are much higher than those of monthly mean temperatures.

Key words: detected climate changes, precipitation, temperature, Hungary.

1. Introduction

Global temperature increased by about 0.7°C in the recent hundred years. Seven from the ten warmest years of the 20th century occurred in the 90's (WMO 1999). As it is known changes were not uniform in space and time, and shifts in average precipitation amounts followed in several regions of the Earth. Changes of precipitation amounts are more interesting for the Hungarian society than those of mean temperatures, since extreme water supply often causes hardship in Hungary. According to Nemes (1996) winter and spring precipitation has decreased since the late 19th century. Similar results are published in Molnár (1996). Szinell et al. (1998) showed that frequencies of moderate and severe drought events became greater in the 20th century. Nevertheless variability of water supply is very large, so the latest years of the 20th century brought as large floods and standing waters as it can be expected once in 50-100 years only.

2. Data Basis

Monthly mean temperatures and precipitation amounts of 14 observing stations from the period 1901-1998 are investigated, as well as daily mean temperatures from 5 of the 14 stations (1901-1996) are also used. All the 14 stations are situated in lowlands. They are clustered into three groups (Fig. 1): 1) Western Hungary is represented by 5 stations around 47°N and 17-18°E; 2) Northern Hungary is represented by 4 stations around 48°N and 21°E; and 3) South-eastern Hungary is represented by 5 stations around 46-47°N and 20°E.

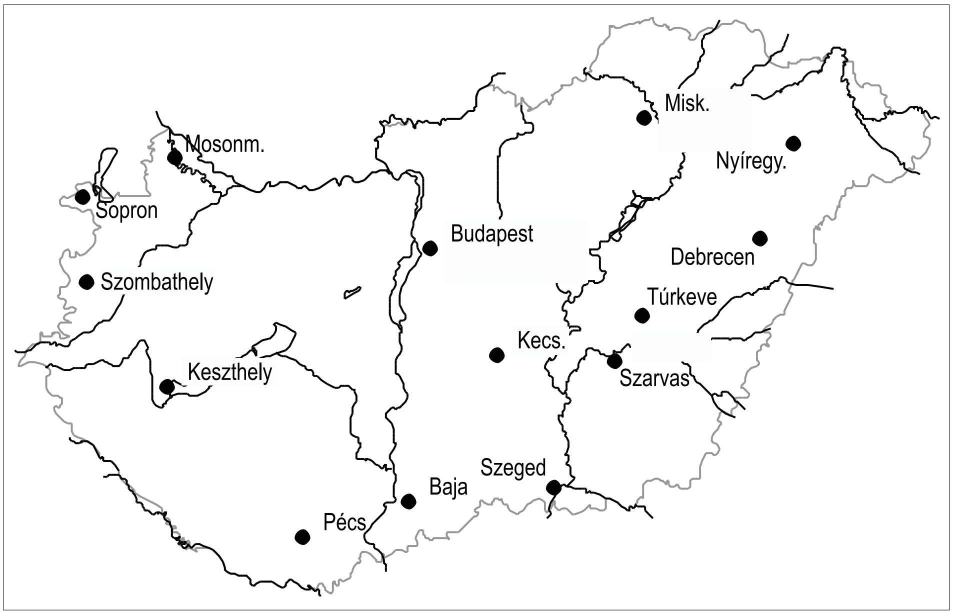

Fig. 1. Geographical positions of the 14 observing stations in the three regions.

Quality of used data is fairly good, however we mention that homogeneity investigations of temperature series have not been finished yet.

3. Methods

Fluctuations are investigated visually at first, using a 15-point Gaussian filter, and fitting different ordered polynoms secondly. Systematic alterations are controlled through linear regression technique completed by t-probe and Mann-Kendall test.

Changes in frequencies of extreme high or low daily mean temperatures are also investigated. Area-averages of daily values of mean temperature series are utilized for these computations. Mean annual changes are filtered and the lowest and highest 5-5 percents of the empirical probability distribution of anomalies were defined as extreme temperatures (Domonkos, Piotrowicz 1998).

4. Changes in Mean Temperatures

In contrast with global trend one can find hardly any systematic change in Hungarian temperatures. In the winter half of the year (October–March) long term fluctuations are small, and curves for the three regions are very close to each-other (Fig. 2). There cannot be seen any systematic alteration during the century. However we mention that in the last 50 years late autumn (October–December) temperatures decreased by 1-1.5°C, and late winter (January–March) temperatures increased by a similar degree. In northern and south-eastern Hungary the late autumn decrease of the latest 50 years is significant at the 0.99 level.

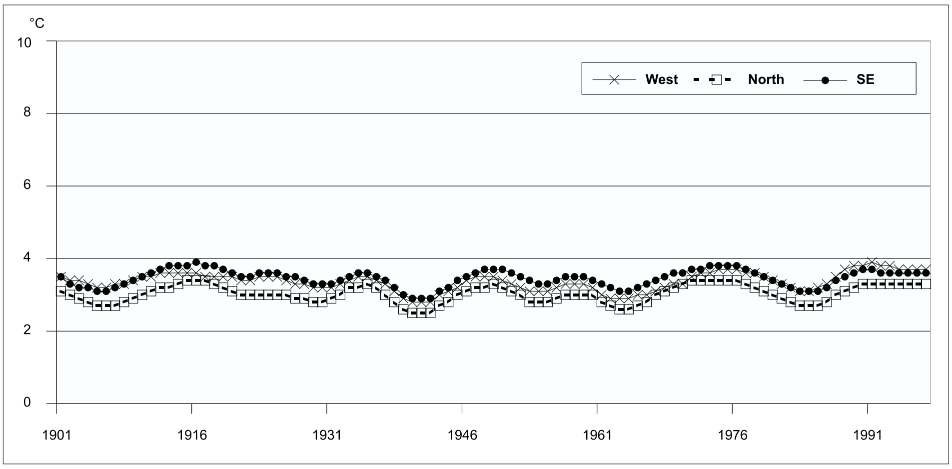

Fig. 2. Changes in mean temperatures of winter half years (October–March).

Fig. 3 shows temperature changes of the summer half years (April–September). During the first half of the investigated period temperature increased by 1-1.5°C. After the mid-century it decreased, and by the end of the 70's it was as low as in the beginning of the century. Since then it has been increasing again, but mean temperature of the 90's is not higher in Hungary, than the average of the previous nine decades.

5. Changes in Precipitation Amounts

Fig. 4 presents changes in precipitation amounts of winter half years. Shapes of the curves for the three regions are considerably similar to each-other. Values for

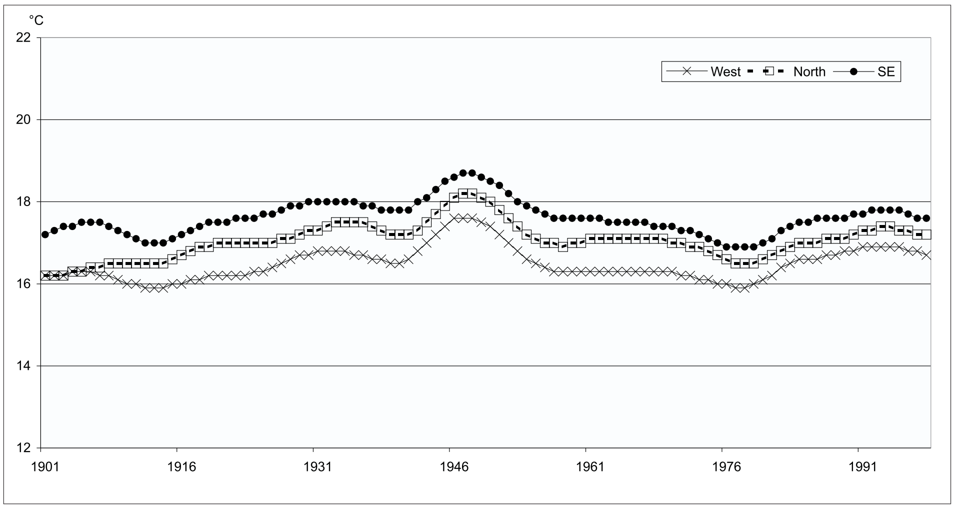

Fig. 3. Changes in mean temperatures of summer half years (April – September).

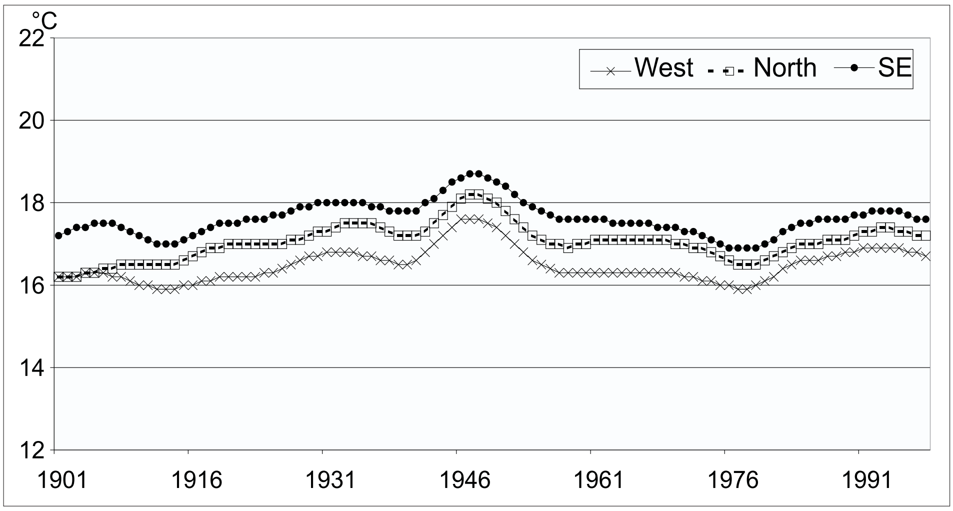

Fig. 4. Changes in precipitation amounts of winter half years.

Western Hungary are higher by about 20-40 mm than those for Northern and SE Hungary. There is no systematic alteration in the first half of the century, but a significant decrease (50-100 mm in 50 years) is present in the second half of the period.

Fig. 5 illustrates precipitation amounts for summer half years. They are generally higher by about 50% than in the winter half years. Values for Western Hungary are

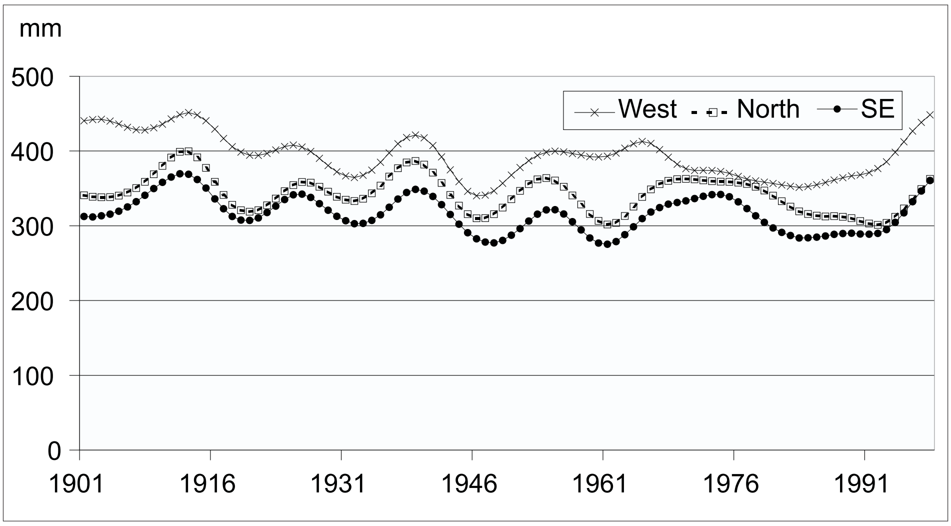

Fig. 5. Changes in precipitation amounts of summer half years.

usually higher by about 60 mm than in the North and by 80-90 mm than in the South-east. Shape of long term changes is close to a parabola in Western Hungary (decrease at first, and increase at the end of the period), while there is practically no systematic change in the other two regions.

Investigating precipitation amounts for individual months statistically significant decreases on the 0.95 level can be found only in five cases. They are the followings: in Western Hungary in April and December, in Northern Hungary in March and October, and in SE Hungary in April. According to this decreasing tendency is most typical for transitional seasons of the year. It is seemingly confirmed by the fact that linear is the best fitting polynom in 71-71% of the 14 local data series for March and October and 57% for April, while this rate is only 33% for other months. Notwithstanding Fig. 6 illustrates that decreases were far not uniform even in these statistically significant cases, and – in contrast with Fig. 4 – the greatest part of falls took place during the first half of the century.

During the last 50 years significant systematic change was not in March, April and October, but precipitation sharply decreased in November, December, January and February. Fig. 7 shows that November–February precipitation amounts slightly increased in the first half of the century, but significantly fell during the second half of that. The rate of the decrease reaches the 20-40% of the mid-century averages. Fig. 6 and 7 demonstrate together that decreasing tendencies were typical in transitional seasons in the first half of the century, and between November and February in the latest 50 years. Summer precipitation do not have systematic alteration in the 20th century.

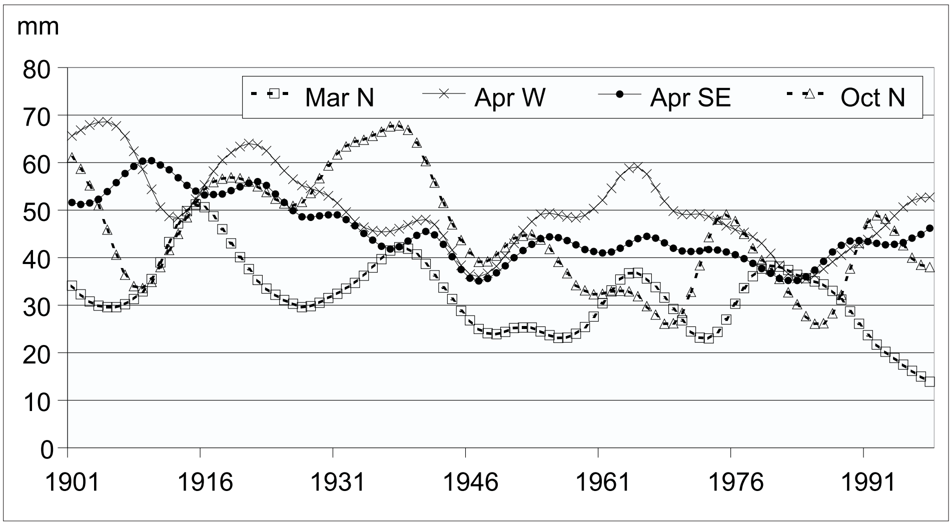

Fig. 6. Changes in monthly sums of precipitation: cases of significant decreases in transitional seasons.

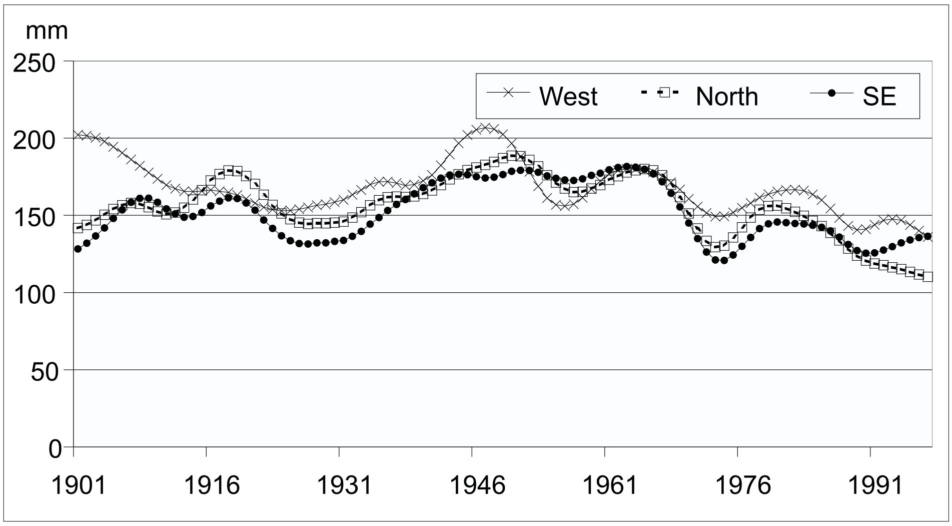

Fig. 7. Changes in precipitation amounts of period November – February.

6. Changes in Frequencies of Extreme Daily Mean Temperatures

Amplitude of long term fluctuations in frequencies of extreme daily temperatures is generally much higher than that of monthly mean temperatures. The widest fluctuations are experienced in extreme high temperatures of late summer (Fig. 8). E.g. in the 40’s the amount of extreme warm days was 5 times higher than in the 10’s or in the 70’s. However, systematic changes are not typical for this meteorological element in Hungary. Fig. 9. presents the only exception: rate of extreme warm days of late winters significantly increased in the century.

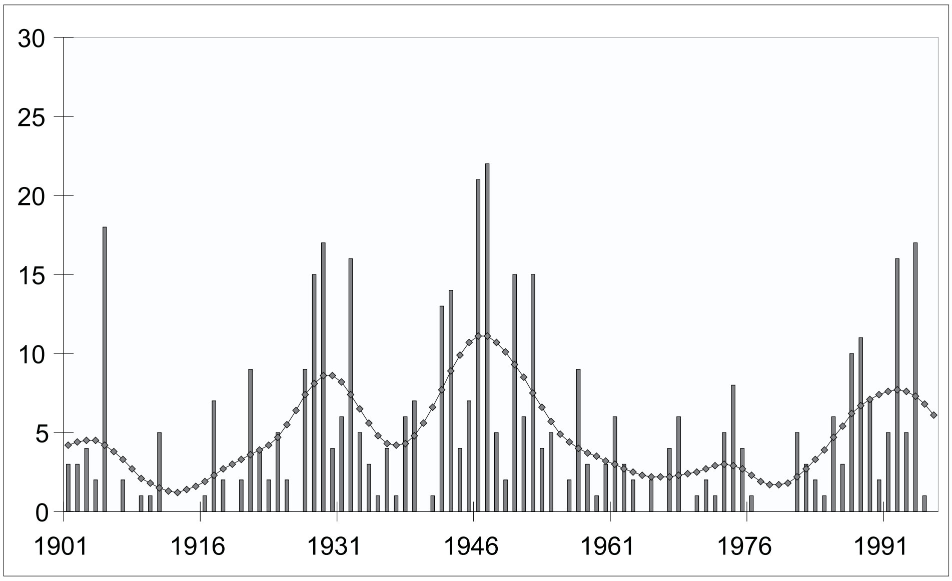

Fig. 8 Changes in annual sums of extreme warm days of late summers (July – September).

7. Conclusions

· Mean temperatures have few systematic changes in Hungary. In contrast with global change mean value for 90’s is not higher than the average of previous nine decades.

· Precipitation amounts of transitional seasons significantly decreased during the century.

· In the latest 50 years significant decrease took place in winter precipitation amounts. Late autumns became colder and late winters are milder than they were in the earlier decades.

· Long term fluctuations of monthly mean temperatures are small, but those of frequencies of extreme daily mean temperatures are spectacularly large.

Acknowledgements

This research was funded by the Hungarian Scientific Foundation (OTKA T029374).

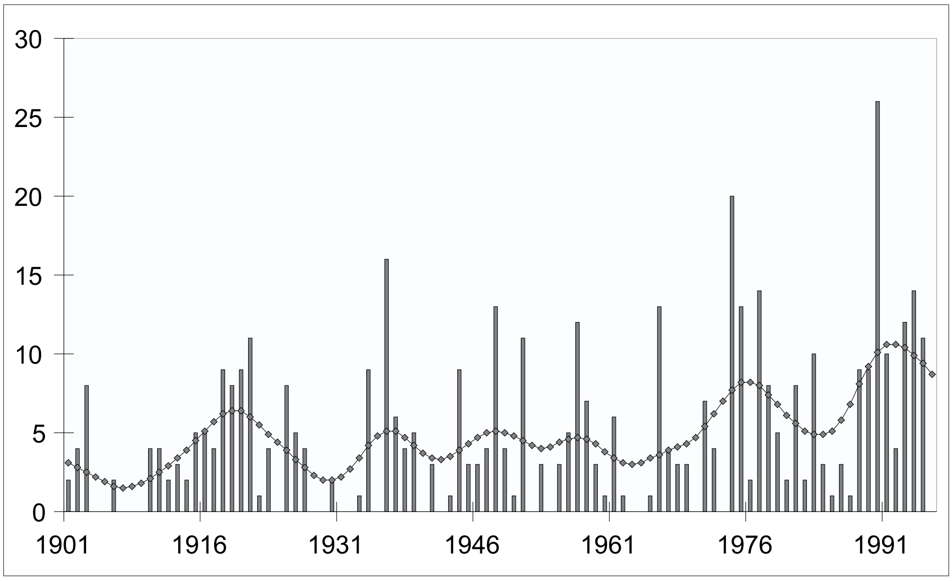

Fig. 9 Changes in annual sums of extreme warm days of late winters (January – March).

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