PRACE GEOGRAFICZNE, zeszyt 108

Instytut Geografii UJ
Kraków 2000

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TEMPORAL VARIABILITY OF THE FREQUENCY OF EXTREME TEMPERATURE OCCURRENCE IN POLAND ON THE EXAMPLE OF ZAKOPANE AND ŁÓDŹ

Abstract: Daily values of minimum and maximum temperature in Zakopane and Łódź were analysed. The minimum temperature indices show the increasing tendencies evident also in the temporal variability of the distribution function. This tendency is probably connected with warmer winter seasons. There is no evidence of trend in maximum temperature series. In this case the lower values occurred at the beginning of present century and in the sixties and the seventies.

Key words: extreme temperatures, distribution function, temporal variability.

1. Introduction

There is a general agreement that the surface air temperature of the world has warmed by about 0.3-0.6^{0}C since the 19th century (IPCC 1995; Jones 1994). This warming trend presents considerable temporal and spatial variability. Karl at al. (1993) have shown that it occurs with association with the increase of daily minimum and maximum temperature, and that the rate of the daily minimum temperature rise is faster than that of daily maximum temperature. Brázdil at al. (1996) have shown that in Poland the linear increase in mean seasonal daily maximum temperature is slightly higher than that of daily minimum temperature in all seasons but autumn during the period 1951-1990. So the diurnal temperature range (DTR) has increased slightly. Therefore the changes are not uniform even on the area of Poland and in the case of Łódź there is a statistically significant decreasing trend of DTR in the period 1931-1996 (Heino at al. 1999).

Has the frequency of extreme events changed during the present century? If so, the extremes in temperature can have significant social and economic impacts. Nicholls et al. (1996) state that although there is no evidence for global changes they probably exist on the regional scale. These changes can manifest not only as a shift of the mean

value but also as variation in other parameters of the extreme values distribution. The aim of this paper is to analyse the long-term course of some indices of extreme thermal events in order to recognize if they have changed considerably during the present century.

2. Data and Methods

The present analyses are based upon daily minimum and maximum temperature series from Zakopane and Łódź. The Zakopane series starts in 1907, the Łódź one starts in 1931. There are some gaps, in twentieths in Zakopane and at the beginning and of The Second World War in Łódź. A few thermal indices were calculated from these data. Three of them concern minimum temperature: annual sum of temperature on days with minimum temperature lower than 0^0C

$$A = \sum_{t_{min}<0} t_{min} ,$$

annual sum of temperature on days with minimum temperature lower than -10^0C

$$B = \sum_{t_{min}<-10} t_{min} ,$$

and the lowest daily minimum temperature

$$C = \min t_{min}.$$

The other two characterise the maximum temperature: annual sum of temperature on days with maximum temperature higher than 25^0C

$$D = \sum_{t_{max}>25} t_{max}$$

and the highest daily maximum temperature

$$E = \max t_{max}.$$

An attempt of estimating of temporal variability of minimum and maximum temperature distributions was also made. To this end the distribution functions of minimum and maximum temperature in different decades were calculated and compared by means of two sample Smirnov test.

3. The Variability of Minimum Temperature

The temporal courses of indices A, B and C are shown at Figures 1-3. There is evidence of increasing trends in all curves. In the case of Zakopane all trends are significant at the 5% level, in the case of Łódź at the 10% level. The conformity of curves for both stations suggests that the increasing tendency of minimum temperature

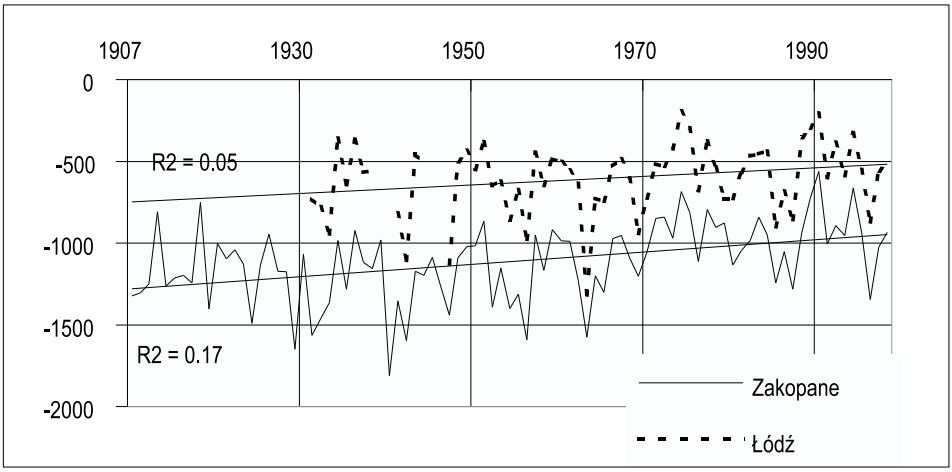

Fig. 1. The course of the annual sum of daily minimum temperature on days with minimum temperature lower than 0^0C.

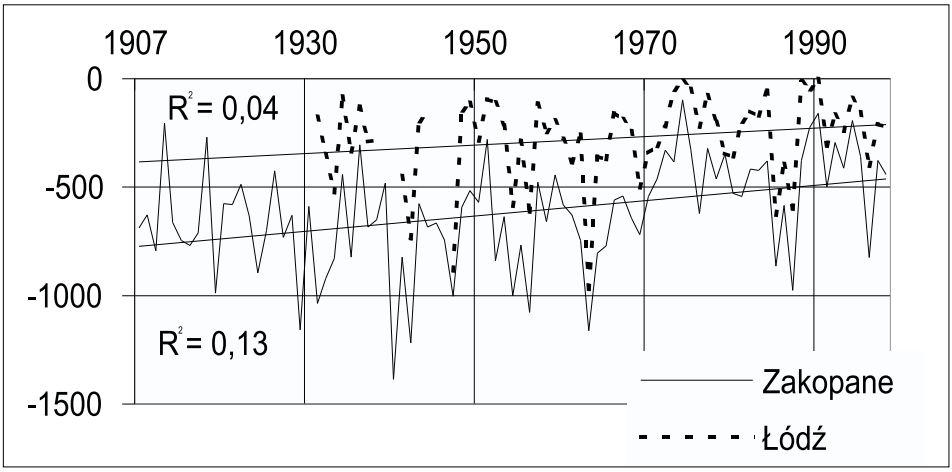

Fig. 2. The course of the annual sum of daily minimum temperature on days with minimum temperature lower than -10^0C.

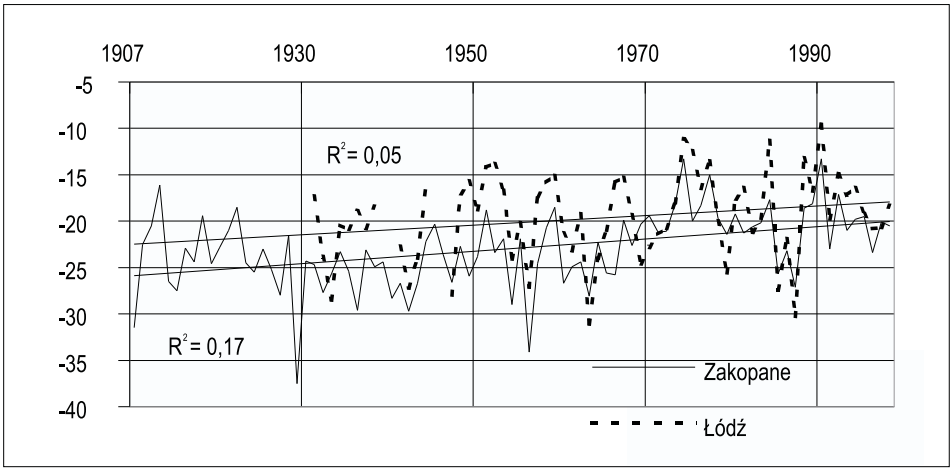

Fig. 3. The course of the annual minimum of daily minimum temperature.

indices is a regional rather than local feature. Figures 4 and 5 present the distribution functions of t_{min} in two the most different decades. In both stations the distribution curves are shifted in the direction of higher values in the last decade (1989-1998) with relatively warm winters. The highest differences concern lower part of the distribution, i.e. minimum temperatures in the colder season. During summer, in the higher part of the distribution, the differences are small and statistically insignificant.

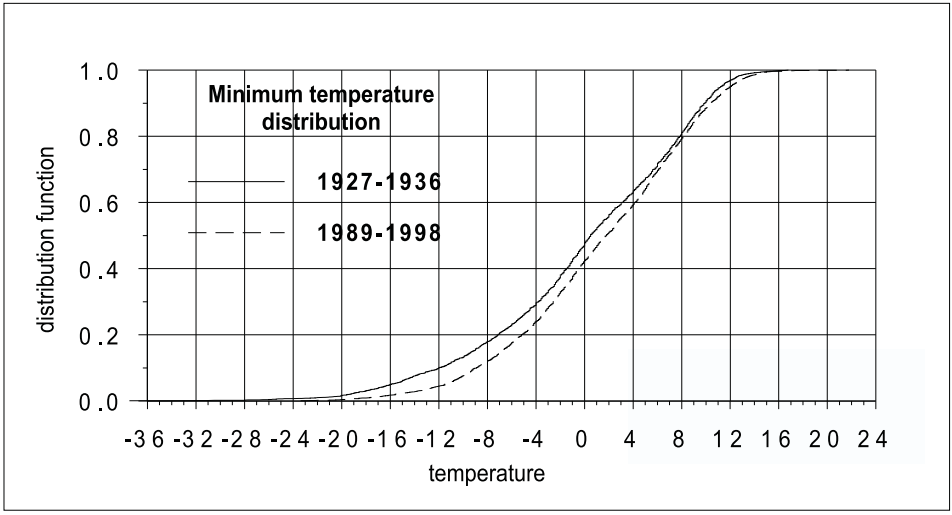

Fig. 4. The distribution function of minimum temperature in Zakopane in two chosen subperiods.

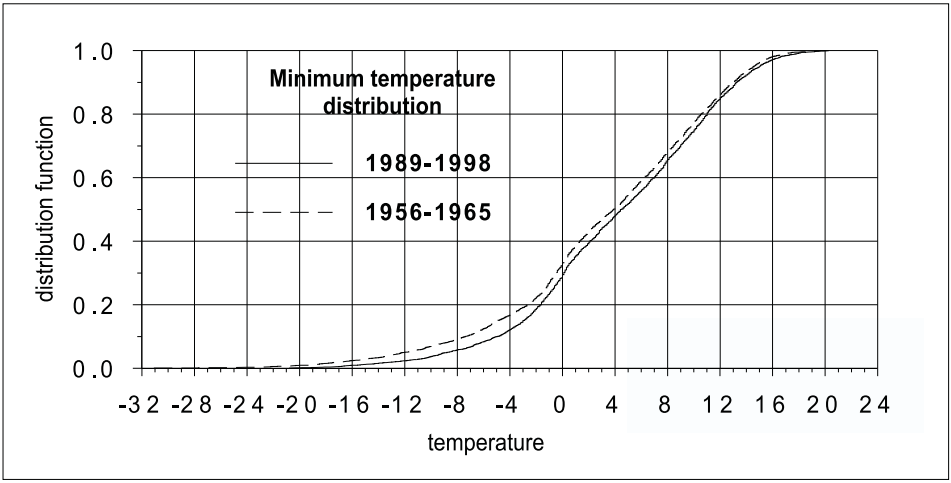

Fig. 5. The distribution function of minimum temperature in Łódź in two chosen subperiods.

4. The Variability of Maximum Temperature

The temporal variability of maximum temperature is completely different. Figures 6 and 7 show the courses of indices D and E. In Zakopane, after the increase at the beginning of present century, the values are relatively high from the twentieths to the fifties. Then there is a drop and after minimum in the end of the seventies they rise

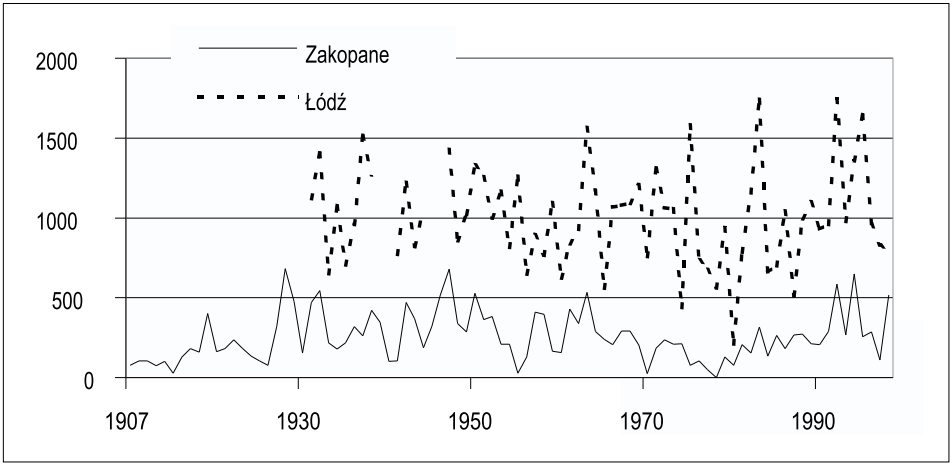

Fig. 6. The course of the annual sum of daily maximum temperature on days with maximum temperature higher than 25^{0}C.

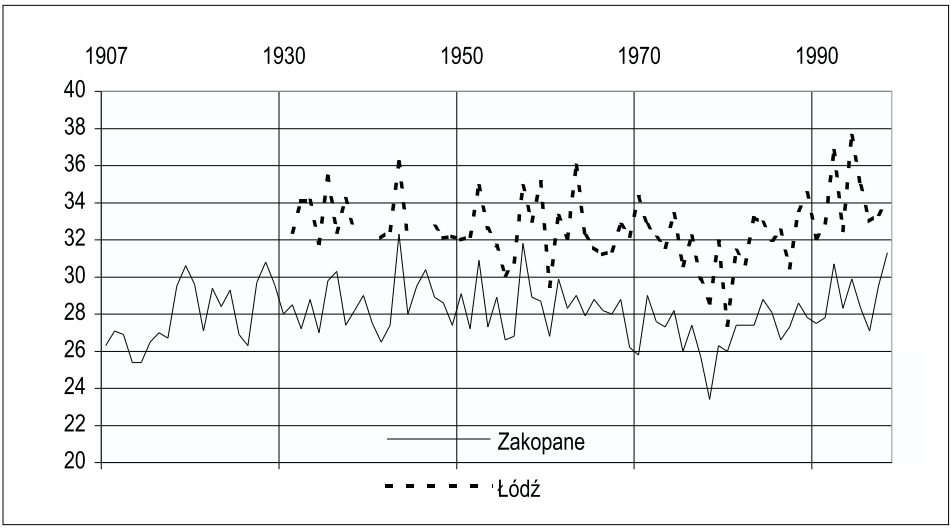

Fig. 7. The course of the annual maximum of daily maximum temperature.

again. In Łódź the course is parallel but it starts in 1931. The comparison of the distribution functions (Fig. 8 and 9) in following decades shows that the highest temperatures occurred in Zakopane at the turn of the twentieths and the thirtieths and in Łódź at the turn of the fortieths and the fiftieths, but the differences in all decades from the twentieths and the

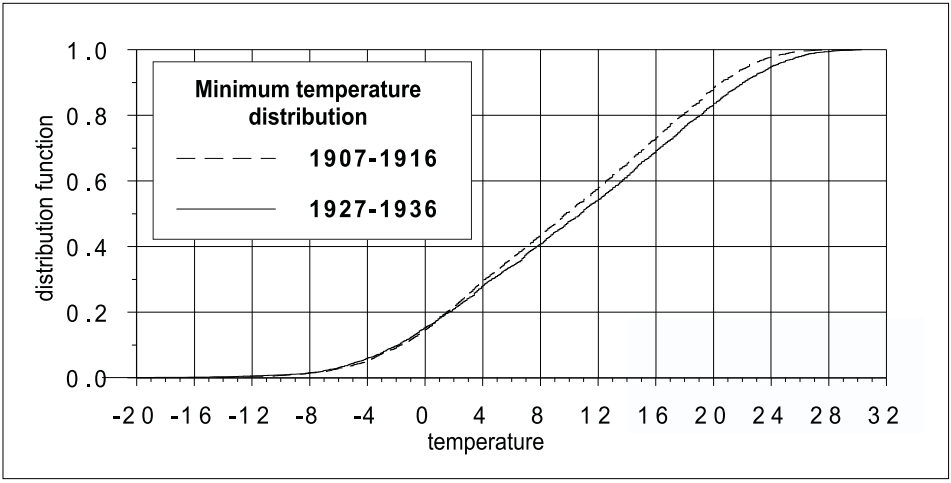

Fig. 8. The distribution function of maximum temperature in Zakopane in two chosen subperiods.

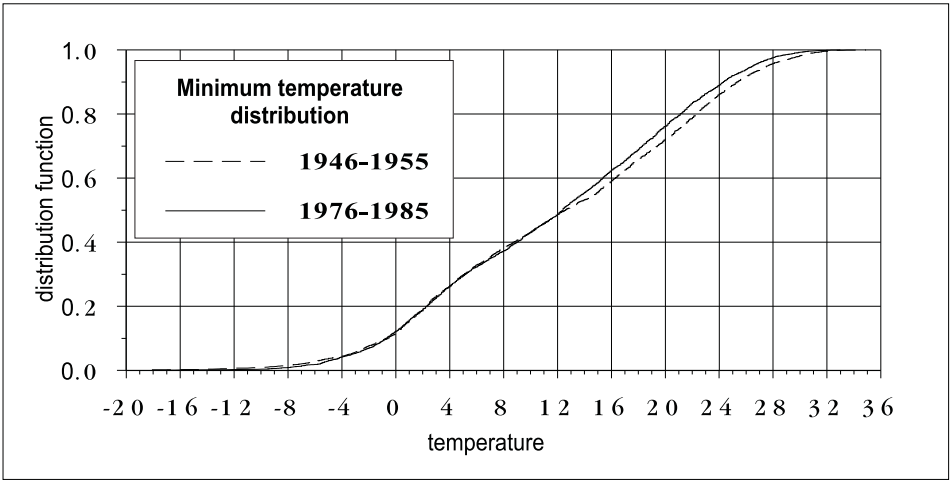

Fig. 9. The distribution function of maximum temperature in Łódź in two chosen subperiods.

fiftieths were rather small. The lowest maximum temperatures in Zakopane were at the beginning of the record (1907-1916) and in Łódź in the period 1976-1985, i.e. during the second minimum at Figures 6 and 7. At this time the greatest differences occur at the higher part of the distribution. It means that they appear during warm season.

5. Conclusions

There is an evidence of increasing tendency of minimum temperature indices, notably in winter season. It may be connected with warming, which is generally more pronounced in winter. The temporal variability of maximum temperature indices is stronger in warm season, but there is no evidence of trend. No final conclusion can be drawn concerning the reasons. To investigate this further, it is suggested to analyse the impact of circulation variability on extreme temperature. The frequency of blocking situations in summer may be responsible for maximum temperature variability, and the strength of zonal circulation in winter may determine the minimum temperature changes.

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