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Seasonal Temperature Extremes in Potsdam

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Abstract

The awareness of global warming is well established and results from the observations made on thousands of stations. This paper complements the large-scale results by examining a long time-series of high-quality temperature data from the Secular Meteorological Station in Potsdam, where observation records over the last 117 years, *i.e.*, from January 1893 are available. Tendencies of change in seasonal temperature-related climate extremes are demonstrated. “Cold” extremes have become less frequent and less severe than in the past, while “warm” extremes have become more frequent and more severe. Moreover, the interval of the occurrence of frost has been decreasing, while the interval of the occurrence of hot days has been increasing. However, many changes are not statistically significant, since the variability of temperature indices at the Potsdam station has been very strong.

Key words: temperature extremes, seasonality, climate variability, climate change.

1. INTRODUCTION

The time series of global mean air temperature, compiled by the Climatic Research Unit of the University of East Anglia, jointly with the UK Met Office Hadley Centre (*cf.* http://www.cru.uea.ac.uk/cru/data/temperature/, Brohan *et al.* 2006) or in NASA in the USA (http://data.giss.nasa.gov/gistemp/), convincingly illustrate global warming.

As noted in IPCC (2007), warming of the global climate system is unequivocal. This is now evident from observations of increases in air temperature, which show clear growing trends at a range of scales, from local, *via* regional, to continental, hemispheric, and global. The updated 100-year linear trend (1906 to 2005) reflects a 0.74°C (0.56 to 0.92°C) global mean temperature increase, while global warming rates over the last 50 years and over the last 25 years were much stronger (0.128°C/decade and 0.177°C/decade, respectively). That is, the global warming rate over the last 25 years is over 2.4 times faster than it was over the last 100 years.

As reported by Trenberth *et al*. (2007), there has been a widespread increase in the number of warm nights between 1951 and 2003, and a decrease in the number of cold nights. Trends in the number of cold and warm days are also consistent with warming, but are less marked than at night. This is a general tendency, yet there are regional differences. Over the last half-century, nearly two-thirds of the global land area have experienced a significant decrease in the annual occurrence of cold nights, while a significant increase in the annual occurrence of warm nights also took place at nearly two-thirds of the global land area. The distributions of minimum and maximum temperatures have not only shifted to higher values, consistent with overall warming, but the cold extremes have warmed more than the warm extremes. More warm extremes imply an increased frequency of heat waves. Associated with the warming there has been a global trend towards fewer frost days.

Although global warming is unabated, one cannot claim that the values of the annual global mean temperature since 1850 are known with good accuracy. Indeed, the uncertainty range has been considerable (but not overshadowing global warming) and has varied with time, being highest in the 1850s and lowest in the 1980s. Since the 1980s, the ground observation networks have been shrinking in many areas, so that recently the uncertainty does not decrease with time.

The paper complements the large-scale aggregate results by demonstrating tendencies for a long time series of good-quality instrumental observation records. It examines the details of seasonal warming *via* analysis of temperature-related climate extremes in the unique long-term gap-free record from Potsdam, from January 1893 to February 2009.

2. DATA

Since the accuracy and homogeneity of a long time series of records of temperature observations is often problematic, it is essential to look for data from highest-quality stations, where the time series of records are long, reliable and gap-free, and where changes of location, surrounding environment, instruments, observation principles and methods, are limited. Such conditions are not easy to find, but they are fulfilled at the Secular Meteorological Station in Potsdam (Germany).

The Potsdam Station (co-ordinates: 52°23′N, 13°04′E, elevation 81 m AMSL) is located to the south-west of town in Potsdam, approximately 600 m away from the built-up area, so that the urban heat island effect is not present there. It is a notable station, probably the only meteorological observatory, world-wide, with uninterrupted observations of many variables carried out every day since 1 January 1893. The Secular Meteorological Station in Potsdam was established with the purpose of serving for a long time (the word *saeculum* means longevity in Latin). The manned observations were continued even during nearly all (except for only three) the days of World War II. Since measurements from self-recording instruments were available and incorporated into the long time series of records, there have been no gaps in the data, even in 1945.

Efforts have been made to keep the observation conditions homogeneous, by maintaining the station location (on an empty plot in Telegrafenberg in Potsdam, in a considerable distance from buildings and trees), the character of the environment (*e.g.*, removing any tree seedlings from station's environment), and methods and principles of instrumental observation (*cf.* Lehmann and Kalb 1993).

Besides air temperature (mean, minimum, maximum), many other meteorological variables are being measured at the station. These include soil temperature, air pressure, relative air moisture contents, water vapour pressure, wind, precipitation, cloudiness, snow cover, frost depth, and sunshine hours. Great efforts have been made to keep the observation conditions homogeneous, by maintaining the station location, conditions of the environment, methods and principles of instrumental observation. Measurements at the station have been carried out three times a day (7:08, 14:08, and 21:08 CET, *i.e.*, UTC + 1 hour). The daily mean temperature is calculated as $(T_7 + T_{14} + 2T_{21})/4$, where T_N represents air temperature at hour N.

In the present internet era, open access to observation records on the web is very important for scientists, decision makers and the broader public alike, and contributes in a substantial way to the awareness on climate variability and change. Time series of daily meteorological records from Potsdam, extending since 1 January 1893, are freely available on the web portal: http://www.klima-potsdam.de/, together with comprehensive information about the station. The station has international reputation and its website has been frequently visited in Germany and abroad (*cf.* Kundzewicz *et al.* 2007, Kundzewicz and Józefczyk 2008).

The diagram of the mean annual temperature observed at Potsdam shows a clear increasing trend (Fig. 1), and the rate of increase grows with time. The slope of the regression line for the last 25 years (1984-2008) was

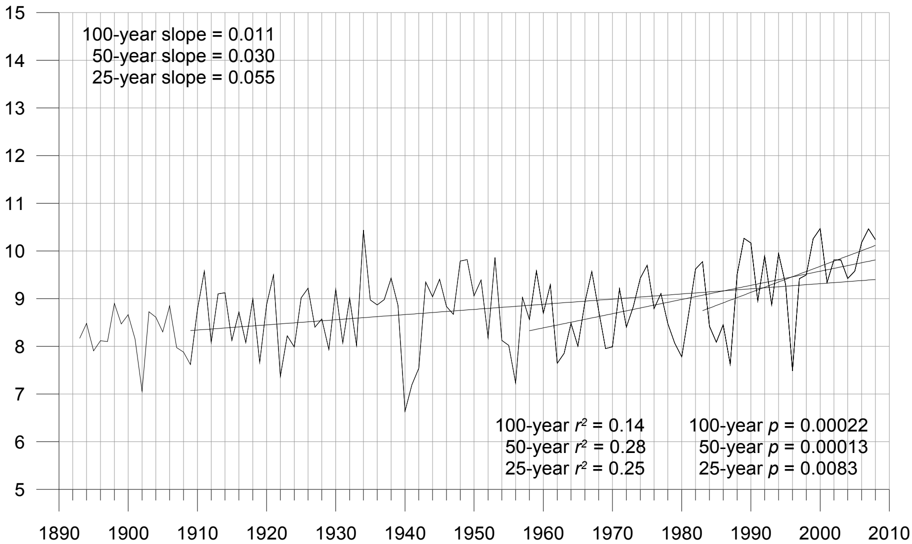

Fig. 1. Changes in mean annual temperature in Potsdam. Notation: r^2 is the correlation coefficient, p is the significance level.

0.55°C/decade, that is nearly twice stronger than during the last 50 years (1959-2008) (0.3°C/decade), and five times stronger than for the last 100 years (1909-2008) (0.11°C/decade). All these changes are statistically significant at the 0.01 level (or better). It should be noted that by shifting the time horizons of regressions in Fig. 2, even slightly, one could get different results. Selection of the last 25, 50, and 100 years for comparison follows the approach taken in IPCC (2007). The present results show that the recent acceleration of warming in Potsdam is much stronger than the global average. There have been eight calendar years on record with a mean annual temperature in excess of 10°C, five of which were in the recent 10 years (Table 1).

Table 1

Mean annual temperature of warmest years in Potsdam

Rank	Year	Mean annual temperature [°C]
1	2000	10.47
2	2007	10.46
3	1934	10.44
4-5	1989, 1999	10.26
6	2008	10.24
7-8	1990, 2006	10.17

The mean annual temperature, which is presented in Table 1, is determined from 365 or 366 values of daily mean temperature (each of which, in turn, is calculated from three values measured every day with 0.1°C accuracy). Presenting of mean annual temperature with 0.01°C resolution allows, for instance, ordering of the years 2000 and 2007. Rounding up to 0.1°C resolution (matching the observation accuracy) would not make it possible to distinguish between the mean annual temperature in these years.

The (upwards) departure from the long-term mean annual temperature in 1934, when the pre-2000 record was settled (the only excursion above 10°C until 1989) was a rare case. But annual mean temperature in excess of 10°C has become much more frequent in the last 20 years (Table 1).

The records of mean annual temperature, presented in Fig. 1, show strong and rapid oscillations. Sudden changes can be noted between two adjacent years, *e.g.*, 1933 (8.02°C) and 1934 (10.44°C), *i.e.*, the difference of 2.42°C, or between 1939 (8.86°C) and 1940 (6.64°C), *i.e.*, the absolute difference of 2.22°C, or – more recently – 1995 (9.29°C), 1996 (7.48°C) or 1997 (9.42°C), *i.e.*, 1.79°C or 1.94°C, respectively. Within the seven-year interval, from 1934 to 1940, the mean annual temperature differed by 3.80°C (from 10.44°C in 1934 down to 6.64°C in 1940).

Departures from the long-term trend, as illustrated by the regression lines, can be strong in individual years. Upwards excursions are a little more frequent, but less pronounced than downward excursions. Deviations of annual mean temperature from the regression line in individual years may even reach 2°C. For instance, the downward excursions from the linear regression in 1940 and 1996 were 2.01°C and 1.78°C, respectively, while the strongest upward excursion in 1934 was 1.85°C.

When looking not only at the annual temperature (in the sense of a calendar year, from 1 January to 31 December), but also at the mean air temperature of any consecutive 12-month period that commences on the 1st of any month, one can find several recent records.

The pre-2007 record of a mean 12-month temperature, 10.70°C (July 1999 – June 2000) has been exceeded six times in 2007, reaching a very high level of 12.09°C in the period from July 2006 to June 2007 (Kundzewicz *et al*. 2007). In the latter record-breaking interval, there were four months with the highest monthly mean temperature ever observed in Potsdam. In July 2006, the mean temperature was 23.69°C (compared to the long-term mean 17.97°C for 1961-1990), in December 2006 it was 5.17°C (long-term mean: 0.69°C), in January 2007, 4.98°C was observed (long-term mean: –0.80°C), and in April 2007, the temperature was 12.02°C (long-term mean: 8.05°C). This last record of highest mean April temperature was broken by more than 1°C in April 2009, to the level of 13.22°C.

After looking at the record of a mean 12-month temperature in 2006/2007 in Potsdam, an analysis was extended to the whole of Germany, most of Europe and the Northern Hemisphere, where records were also detected (Kundzewicz *et al.* 2008).

3. CHANGES IN VALUES OF SEASONAL TEMPERATURE EXTREMES

The long time series of daily minimum and maximum values of temperature in Potsdam were analyzed in the context of seasonal properties for all four seasons. Seasons are defined as MAM (March, April, May) for spring, JJA (June, July, August) for summer, SON (September, October, November) for autumn, and DJF (December, January, February) for winter. Results illustrating seasonal mean of maximum and minimum temperatures for 1893-2008 (in case of winter – including 2009, for 1893 only January and February) are presented in Fig. 2. It shows seasonal warming for all seasons; on average about 1°C/100 years, *i.e.*, 0.1°C/decade. The slope of regression lines for the whole 116-year period varies from 0.0074 (an increase of the maximum temperature for autumn) to 0.0121 (an increase of the minimum temperature for summer). In three seasons, the average increase of the minimum temperature is higher than the average increase of the maximum temperature, except for winter, where the maximum temperature grows slightly faster than the minimum temperature, hence the seasonal amplitude grows. In four cases (spring minimum, summer minimum, summer maximum and autumn minimum) changes are statistically significant at the 0.01 level, while in one case (spring maximum) at the 0.05 level. For three indices (autumn maximum, winter minimum, and winter maximum), changes are not statistically significant at the 0.05 level, while one of them (winter maximum) is nearly significant (0.052).

Climatic time series show strong natural variability (irregular oscillations), which is superimposed on a gradual warming trend. There is a strong random component, so that some record-warm extremes, that occurred a long time ago, have not been exceeded to-date. Cold extremes, even if they occur now, are getting considerably less frequent and less severe. In 1917, the highest monthly mean of daily maximum temperature of June (27.15°C) was observed, even if the climate was then clearly colder than now. Only six years later, in 1923, the ever lowest monthly mean of daily maximum temperature of June (15.62°C) was observed (Kundzewicz and Józefczyk 2008). The warmest spring day ever observed (T_{max} = 34.0°C) occurred on 24 May 1922, the warmest autumn night and day (T_{min} = 18.6°C and T_{max} = 34.0°C) occurred on 4 September 1895. All these "warm" records were set a long time ago, while one of "cold" records – the coldest autumn day observed on 21 November 1993 (T_{max} = –6°C) – was set relatively recently.

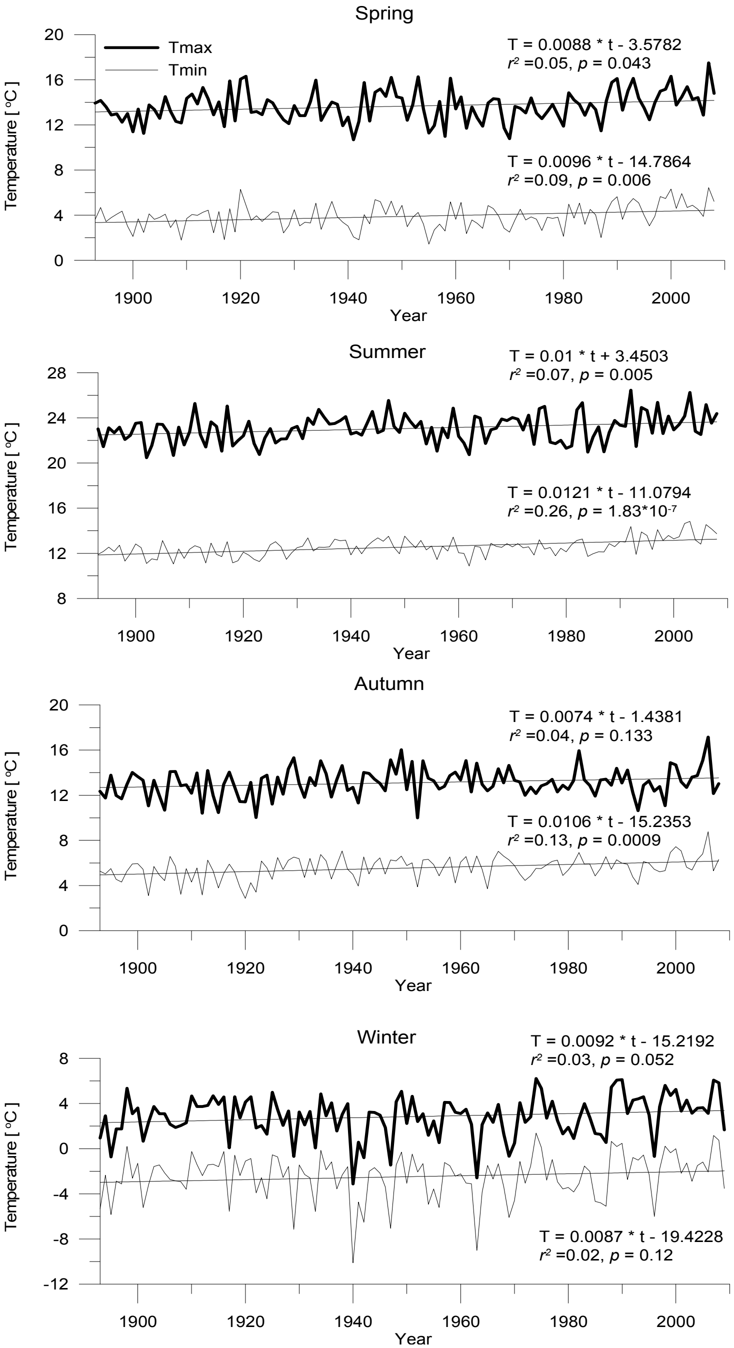

Fig. 2. Changes in seasonal mean of daily minimum and maximum values of temperature for all seasons, in Potsdam from 1893 to 2008.

It is clear that an occurrence of a record-high mean monthly temperature does not necessarily mean that the highest daily maximum temperature in this month is a record high. For example, July 2006 was the warmest July on record, as far as the monthly mean temperature is concerned (23.69°C). However, the highest daily maximum temperature during this month was

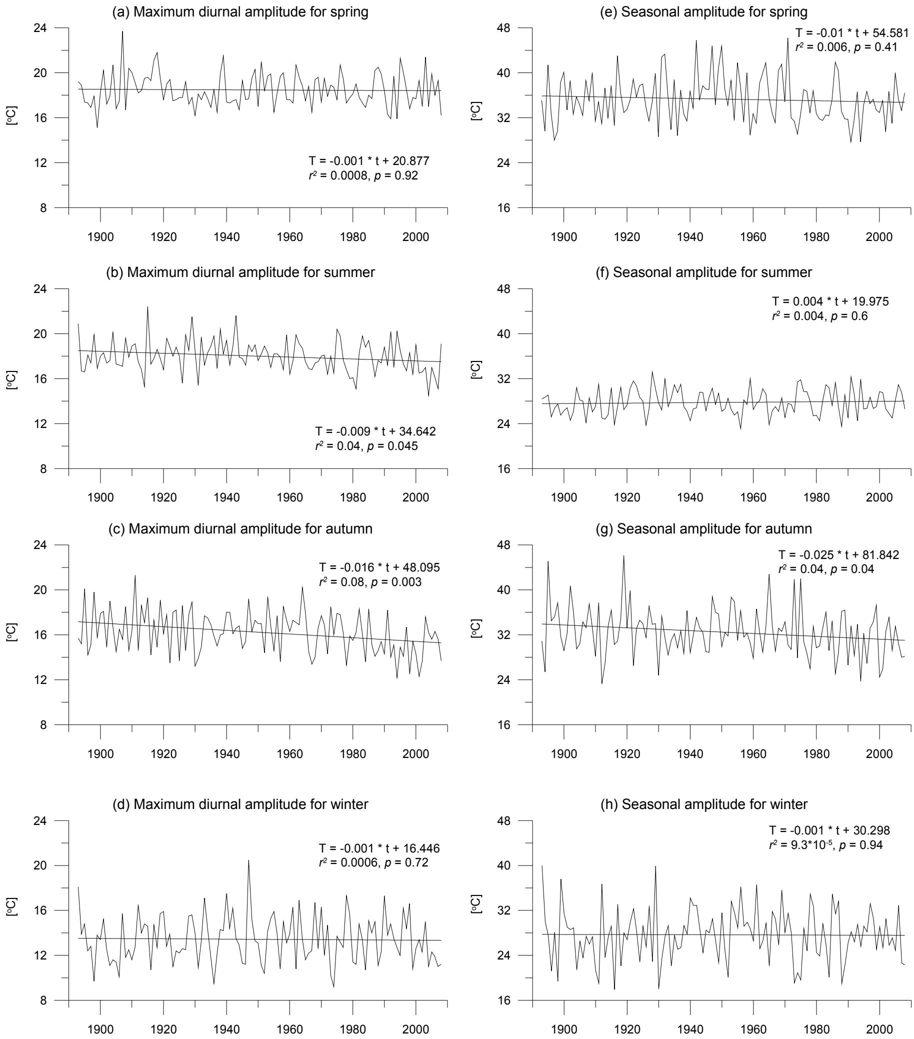

Fig. 3. Time series of temperature amplitudes – maximum diurnal amplitude (difference between maximum and minimum temperature for the same day) for (a) spring, (b) summer, (c) autumn, (d) winter; and seasonal amplitude (difference between maximum and minimum temperature for the same season) for (e) spring, (f) summer, (g) autumn, (h) winter.

35.9°C, that is, below the highest daily maximum temperature of 36.8°C, observed during a much less warm July 2007, when the mean monthly temperature was only 18.05°C.

Most of the intra-seasonal temperature amplitude (understood as the highest difference between daily maximum and minimum temperature in one season, *cf.* Fig. 3a,b,c,d) and the difference between a seasonal maximum and minimum (Fig. 3e,f,g,h) have decreased. The regression slope in all but one of these diagrams is negative, yet in four cases the slope is smaller than 0.005. The steepest slope is for autumn (–0.025 for a seasonal amplitude and –0.016 for maximum diurnal amplitude). Only for seasonal summer amplitude has the slope been positive.

This decreasing tendency is especially strong for the maximum diurnal amplitude in autumn (significant at 0.01 level). However, most (five out of eight) changes illustrated in Fig. 3 are not statistically significant, except for the maximum diurnal amplitude for summer (0.05 significance level) and autumn (0.01) and the seasonal amplitude for autumn (0.05). In the past, the temperature range was much higher. For instance, the lowest and highest autumn temperature values ever observed in 1911-1925 spanned the range from –12.4°C (on 29 November 1925) to +34.7°C (on 3 September 1911).

4. CHANGES IN SEASONAL NUMBERS OF "COLD" AND "WARM" EXTREMES

The numbers of cold and warm days and nights were determined for each season, based on subjective definition of seasonal „cold" and „warm". Alternatively, one could use the percentile-based definitions of these notions, but here impact-based definitions are found more meaningful and easier to interpret by the readership. For instance, the number of excursions of daily minimum temperature below 0°C is far more meaningful than a percentile-based index. Also excursions under the levels of –10°C and +10°C can be intuitively expected as thresholds for a cold night in winter and summer, respectively. The impact interpretation of such thresholds is quite natural. Frosts in spring and autumn jeopardize the traffic (slippery roads), while frosts in spring cause detrimental effects to sensitive crops (*e.g.*, blooming peaches and apricots, walnut, grapes). During a frosty night, some people (in particular the homeless and those under influence of alcohol) may freeze to death and sensitive plants may severely suffer. Cold summer nights adversely impact tourism (*e.g.*, people camping in tents), while heat waves of longer duration adversely affect human health (hyperthermia) and crops.

Figures 4-7 present temporal changes in the numbers of cold nights and days for each season, for the interval 1893-2008 (1893-2009 for winter). The seasonal thresholds for cold nights were selected as –10°C for winter, 0°C for spring and autumn, and +10°C for summer (Fig. 4). The seasonal thre-

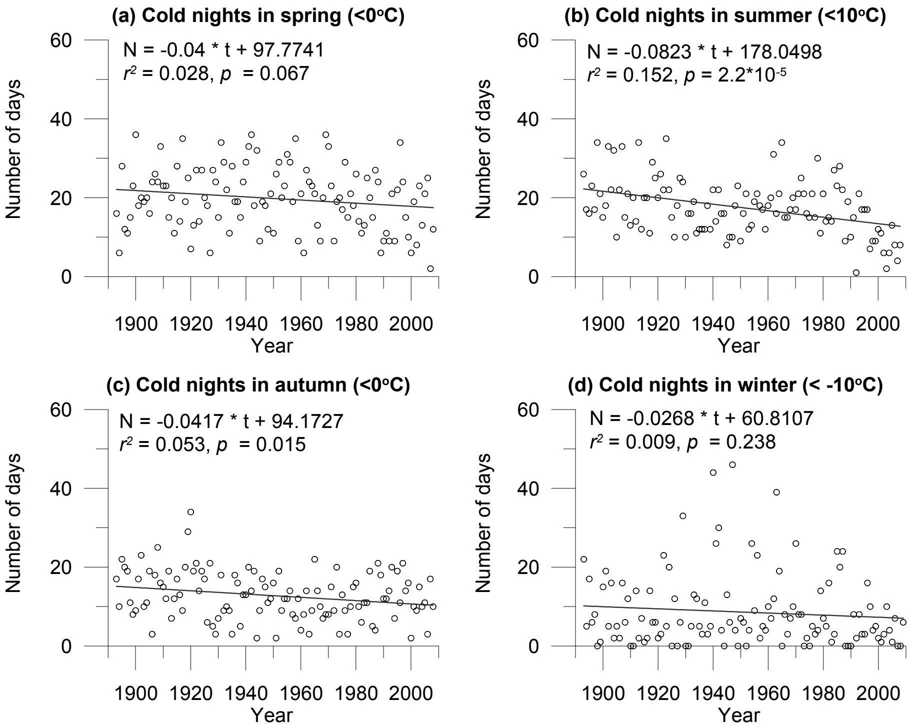

Fig. 4. A time series of the number of cold nights for each season in Potsdam for 1893-2008 (1893-2009 for winter).

sholds for cold days were selected as 0°C for winter, +10°C for spring and autumn, and +20°C for summer (Fig. 5). The seasonal thresholds for warm nights were selected as 0°C for winter, +10°C for spring and autumn, and +15°C for summer (Fig. 6). The seasonal thresholds for warm days were selected as +10°C for winter, +20°C for spring and autumn, and the threshold for hot summer days was +30°C (Fig. 7).

The warm-extreme indicators, such as the number of hot days (with maximum daily temperature exceeding 30°C) were found to increase. In agreement with the warming of winter temperatures, the cold-extreme indicators, such as the number of frost nights (assumed, for simplicity, to be equivalent to minimum daily temperature below 0°C) and of ice days (with maximum daily temperature below 0°C) have been decreasing. In 8 (out of 16) cases presented in Figs. 4-7, changes are statistically significant, at either the 0.01 level or the 0.05 level. In five categories (hot summer days, cold summer nights, cold autumn days, warm summer and spring nights), changes are significant at the 0.01 level and in three categories (warm winter days, cold and warm autumn nights) at the 0.05 level. In the remaining eight categories

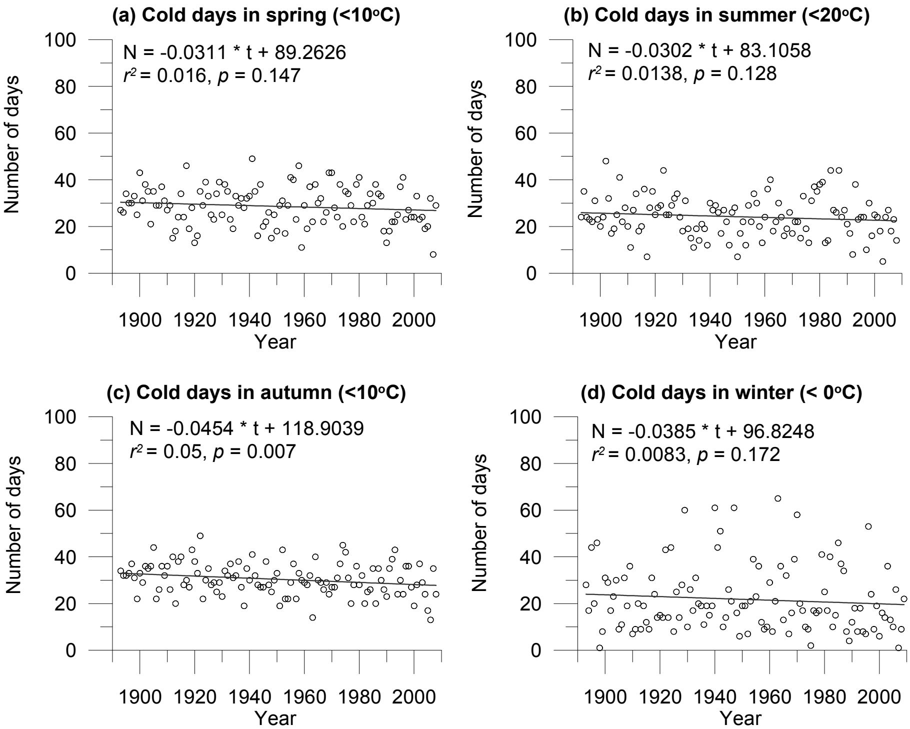

Fig. 5. A time series of the number of cold days for each season in Potsdam for 1893-2008 (1893-2009 for winter).

(cold spring and winter nights, cold days in spring, summer, and winter, warm winter nights, and warm days in spring and autumn) changes are not statistically significant at the 0.05 level. However, low correlation coefficient, r^2, and huge scatter illustrate strong random component (natural variability) of the data points in Figs. 4-7. Seasonal values of temperature indices for a particular year may strongly depart from the mean long-term relation, such as linear regression. This is strongest in winter, and in particular for winter temperature minima, whose drop from the long-term trend in a single year can be very abrupt.

Frost in autumn occurred as early on 2 October (in 1957), while the last spring frost occurred as late on 20 May (in 1952). That is, based on the observations made so far, the absolute frost-free period extends from 21 May to 1 October (132 days). Frost has never been noted on the Potsdam Station in the months of June, July, August, and September. The first hot day, in absolute terms, *i.e.*, a day with T_{max} in excess of 30°C, occurred as early on 22 April (31.8°C in 1968) and as late on 20 September (32.9°C in 1947). That is, in the light of the observations, over a couple of weeks, from

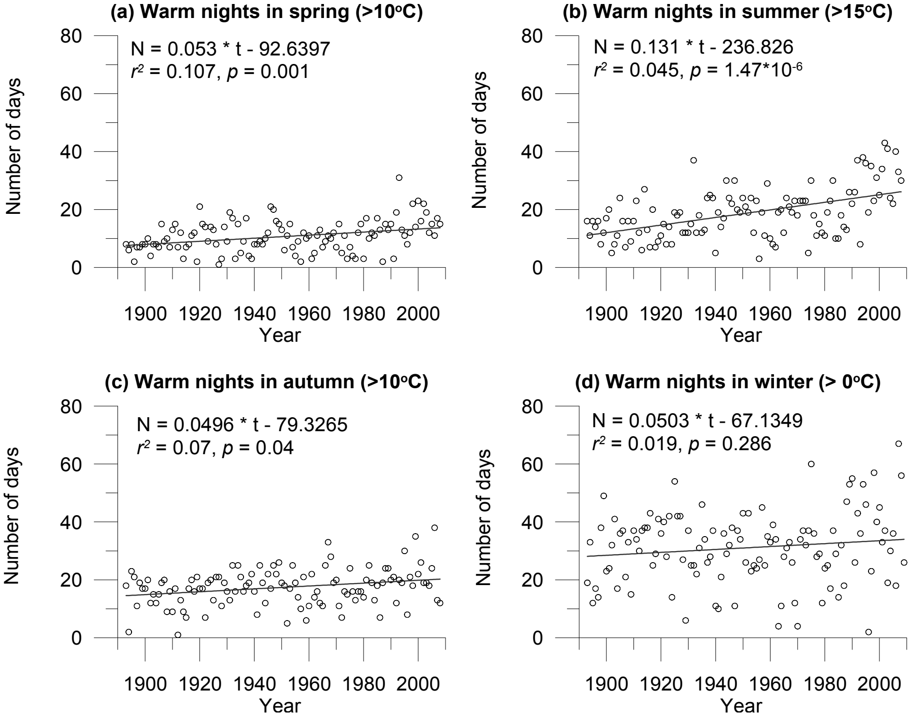

Fig. 6. A time series of the number of warm nights for each season in Potsdam for 1893-2008 (1893-2009 for winter).

22 April (first hot day) until 20 May (last frost), air temperature in Potsdam may as well go down below 0°C (minimum) or rise above 30°C (maximum).

Indicators related to frost and hot days are also illustrated in Figs. 8-10. Figure 8 presents the ordinal number of the last spring frost day ($T_{min} < 0°C$) and of the first autumn frost day. The regression slopes show that the last frost day has been occurring earlier than before in spring but the change is not statistically significant, while in autumn, frosts have been starting later (significance level 0.05). The increasing length of a frost-free interval also indicates a statistically significant (at 0.05 level) warming tendency (Fig. 9) – every decade, the frost-free interval grows, on average, by one day. However, in individual years, departures from the overall trends are very strong. For example, within the last 13 years (1996-2008) both the highest value of the annual number of frost days (133 days in 1996) and the lowest value (52 days in 2007) on record have been observed (Kundzewicz and Józefczyk 2008).

The warming is also accompanied by the increasing tendency of the time span of occurrence of hot days (Fig. 10), but the changes are not statistically significant.

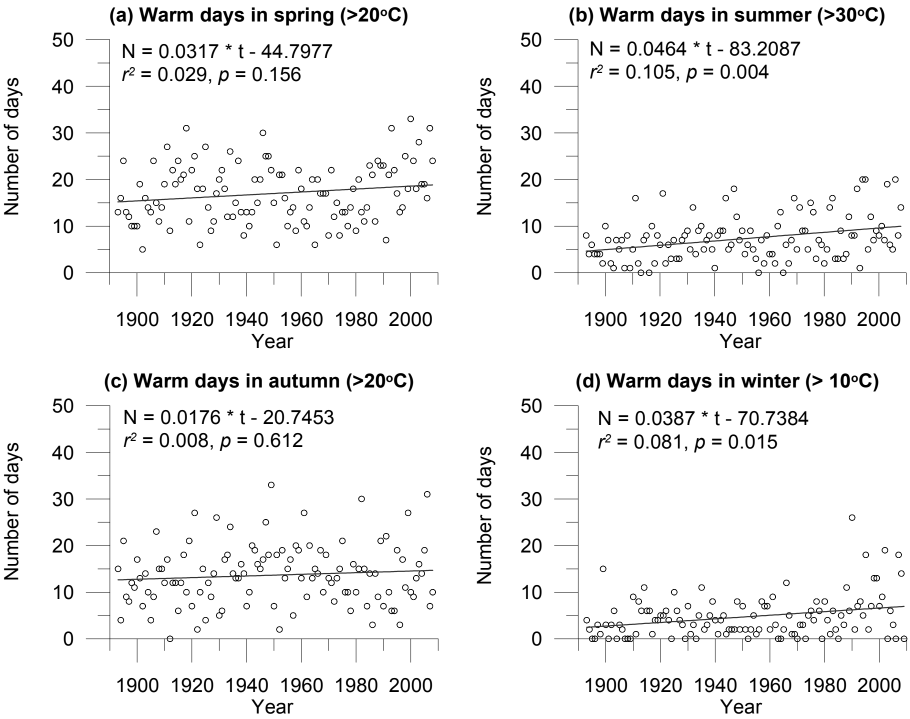

Fig. 7. A time series of the number of warm days for each season in Potsdam for 1893-2008 (1893-2009 for winter).

5. INTERPRETATION OF CHANGES

This paper illustrates a high year-to-year variability of temperature indices, superimposed on a warming trend, based on an analysis of a long time series of high-quality records. One may try to explain the sources of the substantial warming in recent decades, and prior to this, the lack of warming, and even some cooling in the 1950s and 1960s. In IPCC parlance, one needs to address a complex issue of change detection and attribution. Detection is a process of demonstrating that observed change is significantly different (in a statistical sense) from what can be explained by natural internal variability. Once a change is detected, attribution is a process of demonstration that:

- the detected change is consistent with a combination of external forcing including anthropogenic changes in the composition of the atmosphere and natural internal variability; and
- it is not consistent with alternative, physically-plausible explanations of recent climate change that exclude important elements of the given combination of forcings.

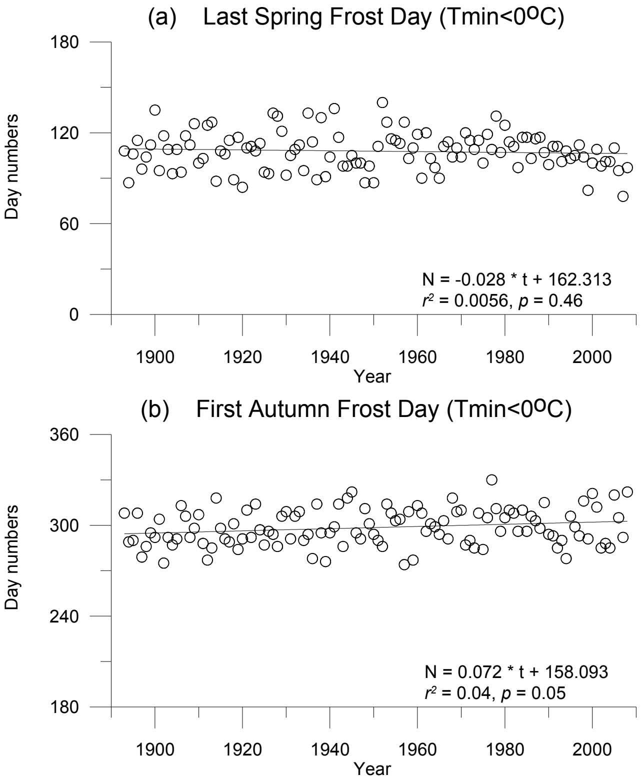

Fig. 8. The ordinal number of the last spring frost day ($T_{\min} < 0°C$) (a) and of the first autumn frost day (b) in individual years. The New Year day is interpreted as day number 1.

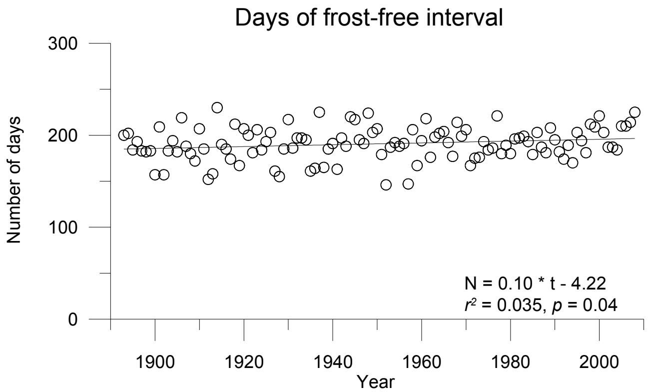

Fig. 9. The number of days of a frost-free interval (for each year last-spring-frost-day-number in Fig. 8 was subtracted from first-autumn-frost-day-number).

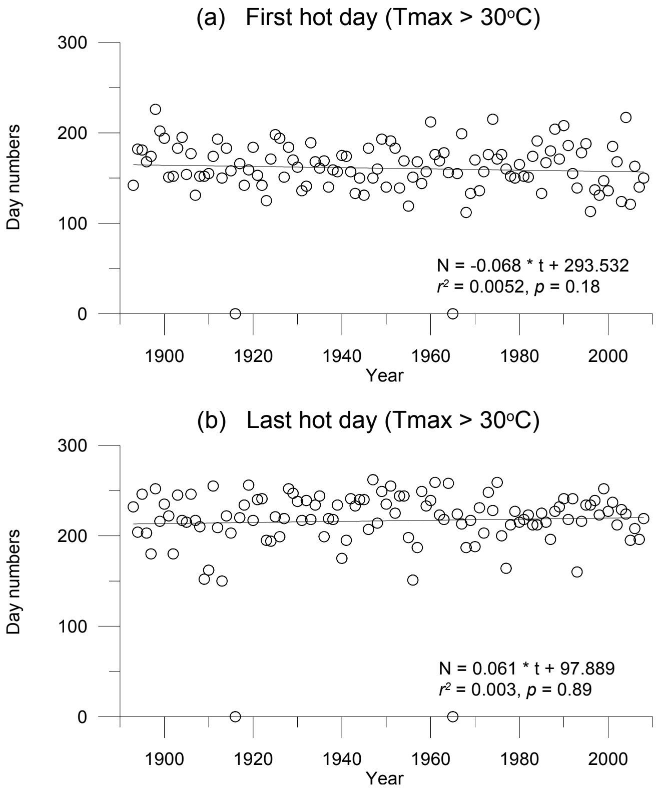

Fig. 10. The ordinal number of the first hot day (T_{max} > 30°C) (a) and of the last hot day (b) for individual years. It should be noted that in two years, 1916 and 1965, there was not even a single day with maximum temperature above 30°C.

A formal process of detection and attribution cannot be carried out for records on a single station. However, the possible mechanisms of change could, and should, also be discussed.

The climate of our planet has been changing globally many times in the Earth's history – there have been many warmer and many colder intervals. Mechanisms of climate change can be divided into the following four groups: (i) changes in the solar activity (*cf.* sunspots number); (ii) changes in orbital parameters (in time scale of tens of millennia, irrelevant to the present climate change); (iii) changes in the composition of the Earth's atmosphere (greenhouse gases – water vapour, carbon dioxide, methane, and nitrous oxide; aerosols; dust); and (iv) changes in the properties of the Earth's surface (albedo, water storage). The first two mechanisms above are purely natural and mankind has no influence on them. The latter two mechanisms can be influenced by both natural and anthropogenic factors. The global increases of concentrations of greenhouse gases (IPCC 2007), which are real and strong, are not sufficient to explain the details of the observed temperature change. The rapid temperature increase observed over Europe (and also at the Potsdam station) in the last three decades is considerably stronger than the mean global warming and the temperature rise expected from anthropogenic greenhouse gas increases. Variability of temperature indices can be partly explained by the oscillations in the system of ocean and atmosphere (notably North Atlantic Oscillations).

Several authors (*e.g.*, Makowski *et al.* 2008, Ruckstuhl *et al.* 2008) found that the aerosol and cloud-induced radiative forcing could explain a portion of the recent changes in temperature indices in Europe.

Solar irradiance measurements on the Earth's surface illustrate considerable changes. An interval of global solar dimming and subsequently – an interval of global solar brightening (continuing to-date) have been noted that cannot be explained by variations of the Sun's activity. The explanation is sought in the changes of atmospheric transmittance due to increases and subsequent decreases in anthropogenic aerosol concentrations, cloud-mediated aerosol effects, and direct cloud effects. In Europe, sulphurous emissions have grown since the 1950s, then peaked in the early 1970s in Western Europe, and in the late 1980s and the early 1990s – in Eastern Europe, and decreased since then. A reduction in anthropogenic aerosol concentrations in Western Europe, since the late 1970s and the early 1980s, resulted from considerable efforts undertaken in many countries to curb air pollutant emissions. The decrease in Eastern Europe can be partly associated with the economic collapse of the communist system, dominated by heavy industry, responsible for the high level of air pollution.

Aerosols affect atmospheric transmittance and hence temperature via the direct aerosol effect (scattering and absorption of sunlight by aerosol particles). There also exist, however, cloud-mediated indirect aerosol effects, such as the cloud albedo effect (enhancement of cloud albedo due to smaller droplets) or the cloud lifetime effect (extension of cloud lifetime due to smaller droplets and less precipitation loss), *cf.* Ruckstuhl *et al.* (2008). Clouds simultaneously affect solar shortwave and thermal longwave radiation but with opposite sign. Hence, the total cloud effect is the sum of the negative shortwave cloud effect and the longwave cloud effect (in which water vapour functions as a greenhouse gas), that partly compensate each other.

The findings of this present paper, illustrated in Fig. 3a, b, c, d, show that the maximum diurnal amplitude observed in Potsdam has decreased with time for all seasons, but only for summer and autumn are the changes statistically significant (at levels 0.05 and 0.01, respectively). However, there is a very strong variability around decreasing trends of seasonal maximum diurnal amplitude.

These findings can be indirectly compared to the results of Makowski *et al.* (2008), who investigated annual mean diurnal temperature range (DTR) for the period 1950-2005 for 23 different countries and regions in Europe as well as Europe as a whole. They demonstrated that the long-term trend of DTR has reversed from a decrease to an increase during the 1970s in Western Europe and during the 1980s in Eastern Europe. For the 16 out of 23 regions studied, as well as for the European mean, there was a statistically significant period of decrease and a subsequent increase in DTR. Of the remaining seven regions, two show a non-significant increase, three show a significant decrease and two reflect no significant trend (therein the eastern part of Germany, where Potsdam is located).

The diurnal temperature range is a suitable measure to investigate the counteracting effects of longwave and shortwave radiative forcing, because the diurnal minimum is closely related to the longwave radiative flux, while the diurnal maximum is predominantly determined by shortwave radiation. Makowski *et al*. (2008) find that the long-term trends in DTR are strongly affected by changes in incoming shortwave radiation (undergoing a dramatic change from dimming to brightening), presumably largely influenced by the direct and indirect effects of aerosol from SO_2 emissions.

6. CONCLUSIONS

Besides conducting the studies of change detection in mean temperature data, the research community has been carefully watching temperature extremes in different categories, such as the maximum and minimum daily, monthly, seasonal, and annual temperatures. The present paper indicates that global and general findings of ubiquitous warming are in general agreement with temperature extremes in a specific, long-term, high-quality observation record. However, it shows that the natural variability at a single station is very strong and that extremes in a single year may largely differ from the dominating tendency. Absolute record values of maximum or minimum temperature do not necessarily match the trend present in the long-term time series. It can be clearly seen that high values of „warm" extremes (such temperature-related indicators as seasonal maximum and minimum temperatures, number of hot days) may have occurred many decades ago, when the level of warming (as indicated by the linear regression) was much lower. Similarly, despite the warming, cold extremes may have occurred in recent decades, largely differing from the value corresponding to the decreasing tendency.

Hence, one has to be careful with the interpretation of warming. Rather than re-iterating the global warming statement with every exceptional warm spell and questioning it with every exceptional cold spell (*e.g.*, January 2010), as often done in the media, one needs to take a more balanced view with consideration of old records and natural variability. Contrary to common interpretation, climate vagaries have always been strong. This should be remembered even if there is a tendency for "cold" extremes to become less frequent and less severe and for "warm" extremes to become more frequent and more severe.

A formal process of change detection and attribution in temperature indices at the Potsdam station cannot be carried out. However, possible mechanisms of change were discussed, including the link between air pollution and warming. The analysis of data at a baseline station where long time series of records are available allowed the authors to contribute to a more general debate, in which the data series are typically much shorter and of lower quality.

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