Abnormally cold and warm temperature events in spring and autumn in the Czech Republic

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1 Introduction and objectives

Today a great attention is turned to the changes in extreme weather events under the changing climate as they could have a great impact on socio-economic sectors. Concerning the air temperature, the extremes in warm and cold parts of the year are mostly studied. However, the negative impacts (e.g. for vegetation or consumption of energy for heating) are connected to the changes in extremes of minimum and maximum temperature in spring and autumn seasons as well. In addition, strong extreme events in spring and autumn have recently been recorded in the Czech Republic (e.g. cold March 2013, warm April and May 2018 or September 2016).

In present contribution we focus on abnormally cold and warm air temperature events in spring and autumn seasons in the Czech Republic in the period of 1961-2018. The abnormal air temperature events are detected using the standardized data and Weather Extremity Index (WEI) combining return periods and the extent of affected area. The temporal evolution of frequency of occurrence during the period of 1961-2018 is analysed.

2 Data and methodology

I. Data Data of daily maximum (Tmax) and minimum (Tmin) air temperature from climatological database CLIDATA operated in the Czech Hydrometeorological Institute have been used for abnormal events detection. The seasonal mean air temperature and seasonal mean of Tmax and Tmin over the Czech Republic have been used for trend analysis .

II. Standardized data Because the seasonal extreme events detected from station data usually occur at the beginning and by the end of spring and autumn due to the annual course of air temperature, the standardized data with removed annual course are used to detect the abnormal events. The distribution of Tmax and Tmin is standardized for each station and each calendar day with the standard z-score using time-smoothed mean and standard deviation.

III. Weather extremity index The abnormally cold and warm events are detected using the Weather Extremity Index (WEI) described by *Müller and Kašpar (2012).* In the first step of the procedure the rarity of Tmin/Tmax at individual meteorological stations is evaluated, observed values are transformed into return periods estimated using generalized extreme value (GEV) distribution. The return periods are then interpolated into regular grid with 1 km horizontal resolution. Interpolated return periods from the whole area of the Czech Republic are ordered from highest to lowest. Then we look for the optimal number of grid points from this ordered sequence (which represent area affected by the extreme event) where the normalized extremity reaches its maximum.

$$WEI = \max_{n=1\ldots M}\left(\frac{\sum_{i=1}^{n}\ln(N_i)}{\sqrt{\pi a}}\right),$$

where N_i is the return period in grid point i, a is the area equivalent to n grid boxes and M is the number of grid points over the Czech Republic.

The WEI has been calculated not only for the daily data but also for the several-days averages of Tmin and Tmax. Thus the extreme several-days (up to 7-days) averages have been considered in abnormal events detection as well.

3 Trends of seasonal mean air temperature

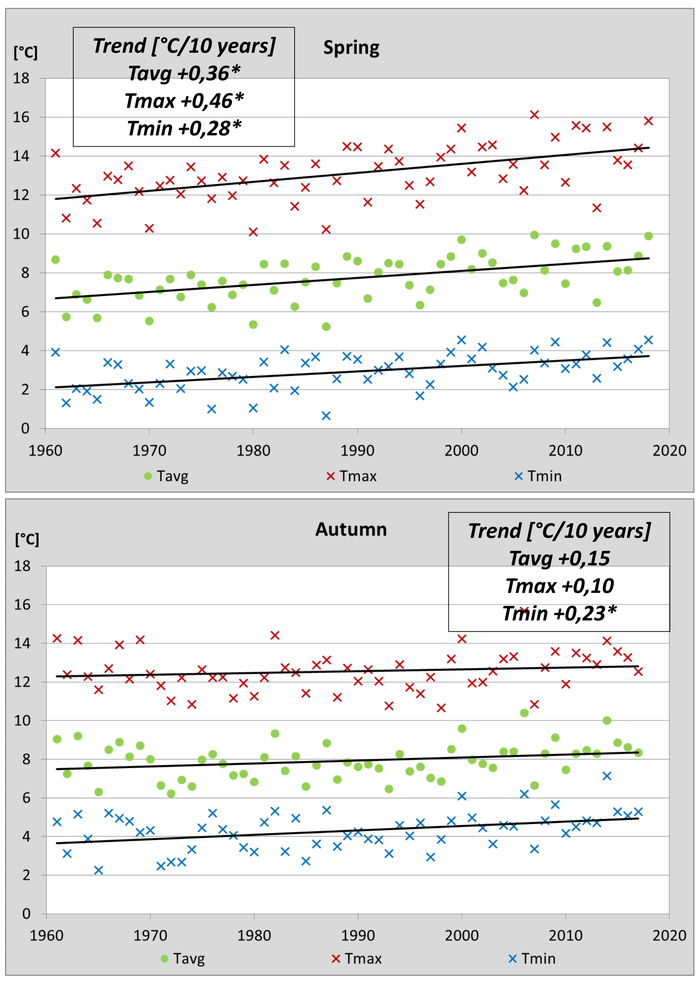


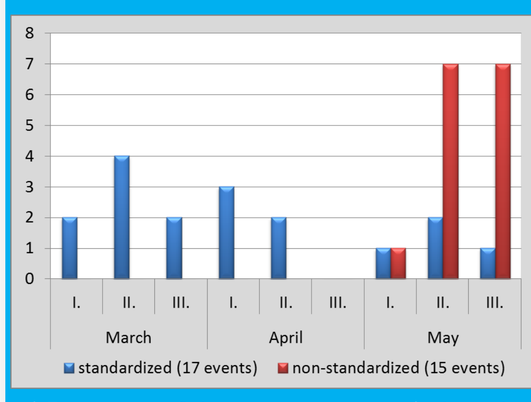
Fig. Seasonal mean air temperature (Tavg), seasonal mean of daily maximum (Tmax) and minimum (Tmin) air temperature for spring and autumn seasons over the area of Czech Republic

The observed linear trends of seasonal Tavg, Tmin and Tmax in the period of 1961-2018 for spring and 1961-2017 for autumn are positive. In spring, the trends are statistically significant at 5% level. In autumn, only the trend of Tmin is statistically significant.

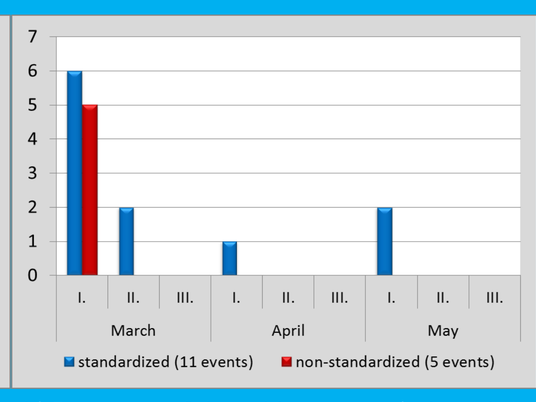
The trends are stronger in spring than autumn. In spring, the highest trend was found for seasonal Tmax and the lowest for Tmin. In contrast, the highest trend was found for Tmin and the lowest for Tmax in autumn.

4 Distribution of extreme events over the season

While the abnormally warm and cold events determined from non-standardized data are accumulated in the edges of seasons due to annual coarse of temperature, the extreme events determined from standardized data are distributed more evenly in the season.



a) Frequency of the warmest events (selected via WEI) in ten-day sections in spring season.



b) Frequency of the coldest events (selected via WEI) in ten-day sections in spring season.

The increased frequency of the cold events determined from standardized data in the first ten-day section of May might indicate the spring singularity of sudden temperature drop in the first half of the May typical for central Europe.

5 The temporal evolution of abnormally warm and cold events frequency during the period of 1961-2018

The abnormally warm and cold events were selected for spring and autumn seasons using WEI (the events with WEI > 200). Afterwards, the strongest of these events were selected as the events with WEI > 300 and WEI > 400.

The decadal frequency of selected abnormal events and the strongest of these events is used to assess the temporal evolution of their frequency in the period of 1961 – 2018.

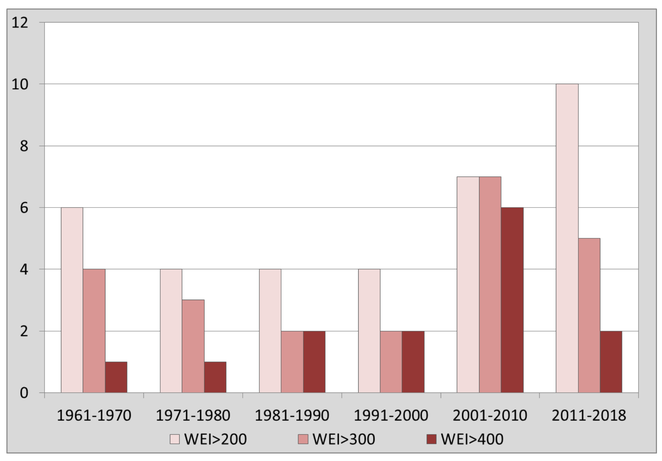
Warm events in spring and autumn

The frequency of abnormally warm events in spring increased noticeably in the last two decades (2001-2010 and 2011-2018). If we consider only the strongest events (WEI > 400), the highest frequency is detected in 2001-2010. Similarly, the frequency of abnormally warm events in autumn is considerably higher in the last two decades.

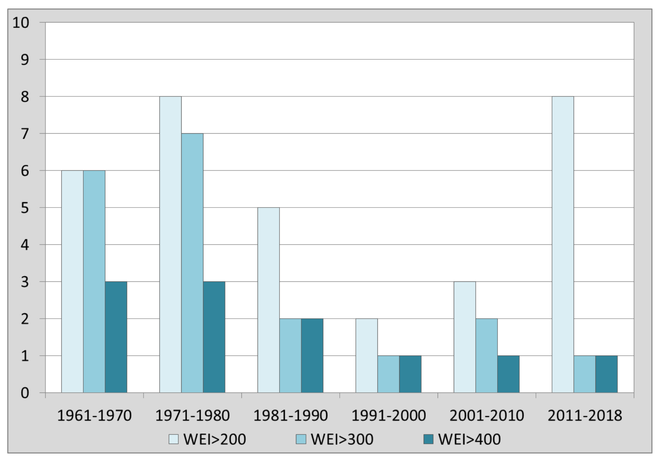
Cold events in spring and autumn

The frequency of abnormally cold events in autumn decreased obviously in last two decades. In addition, the cold events are weaker in these decades (no event with WEI >400 occurred).

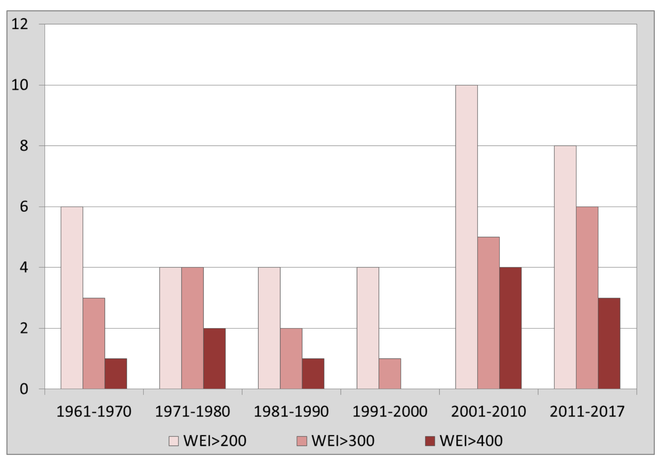
Surprisingly, the lowest frequency of abnormally cold events in spring occurred in decade 1991-2000 and the frequency is rising in the last two decades again. However, the frequency of the strongest cold evets is lower in last three decades (1991 – 2018) than in 1961 – 1990.



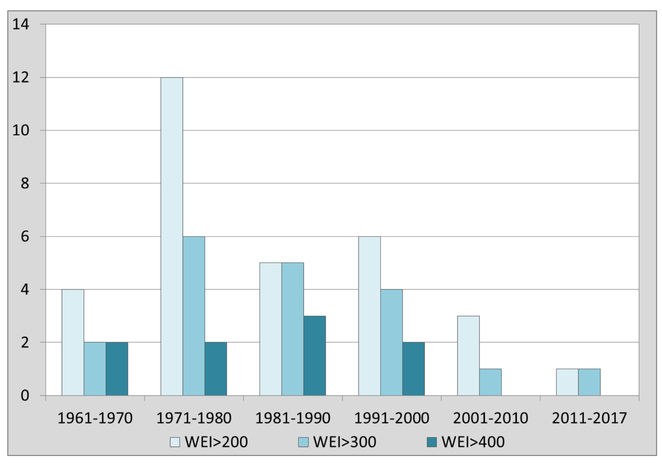
a) Frequency of warm events in spring during the period of 1961-2018.



b) Frequency of cold events in spring during the period of 1961-2018.



c) Frequency of warm events in autumn during the period of 1961-2017.



d) Frequency of cold events in autumn during the period of 1961-2017.

6 Conclusion

- An increase in frequency of abnormally warm events in spring corresponds to the statistically significant positive trend in seasonal temperature.
- Although the trends in seasonal Tmax and Tavg in autumn are weak and not statistically significant, an increase in frequency of abnormally warm events is considerable.
- A decrease in frequency of abnormally cold events in autumn corresponds to the statistically significant positive trend in seasonal Tmin.
- Although the positive trend in seasonal Tmin in spring is statistically significant, the frequency of abnormally cold events is not decreasing. However, the cold events seem to be weaker than in previous years (1961-1990).

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References: ***Kašpar M. and Müller M., 2012.*** *Dynamical Evaluation of Precipitation extremity, 9th International workshop on precipitation in urban areas, Urban Challenges in Rainfall Analysis 6-9 December, 2012, St. Moritz, Switzerland*