MINIMUM AIR TEMPERATURES GOING TO EXTREMES IN BRASOV CITY (ROMANIA)

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Abstract: Brașov is the largest city in the Romanian Carpathians. It mainly lies under western mid-latitude climatic interferences, with well-defined local features as a result of relief configuration. The main objective of this study is to make a detailed analysis of minimum air temperatures, highlighting their extreme values. A specific set of products, generically called indices of extremes and climate change by the WMO's *Expert Team on Climate Change Detection and Indices* (ETCCDI) were calculated based on the climatologic data provided by the Brașov-Ghimbav station over the 1980-2015 period. The practical importance of these quantitative assessments is given by the fact that they can be useful tools in calculating technical parameters which are relevant for the design of heating or cooling installations, in order to maintain a comfortable indoor climate.

Key words: minimum air temperatures, indices of extremes, Brașov city, Romania.

Introduction

Brașov city is located in the Brașov Depression and it is the largest city in the Romanian Carpathians (Figure 1) (Ielenicz, 2005). Brașov is the residence of the homonymous county and is located at an average altitude of 625 m. Its territory extends along the inner slopes of the Curvature Carpathians, more precisely, at the feet of the Postăvaru massif, with its extension - Tâmpa Mount, and the Piatra Mare Mts. (Județele Patriei, 1981). This city is constantly expanding, so settlements are developing strongly (Posea, 2006).

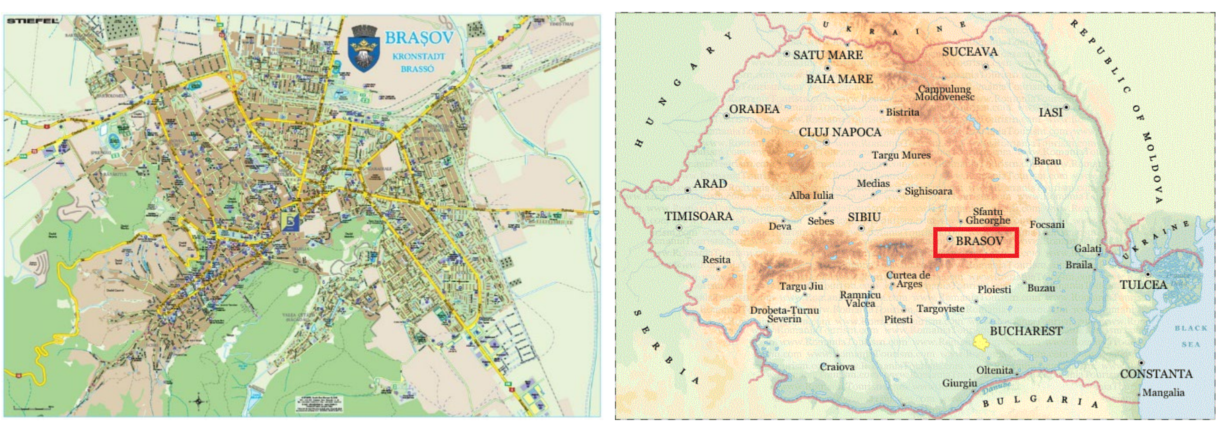

figure 1. Brașov city plan (left) and its geographical position in the central part of Romania (right) (Sources:http://www.businessmap.ro/portofoliu-proiecte/harta-personalizata-municipiul-brasov-pentru-brahouse/ and https://romaniatourism.com/romania-maps/physical-map.html)

It mainly lies under western mid-latitude climatic interferences, with well-defined, local features as a result of relief configuration. The main climatic aspects highlighted by the existing literature, as well as those recorded by the Ghimbav weather station show the predominantly western type of atmospheric circulation, with winters often getting excessive character of continentalism, especially when a branch of the Crivăț wintry wind, locally called Nemira blows over this area or when strong temperature inversions occur (Ciulache & Ionac, 1997).

The average amount of precipitation is 600 mm per year, the relative humidity is often over 80%, and when combined with temperature inversions, low Stratus clouds or radiation fogs may appear (Bogdan, 1999).

1. Data and methods

The most representative weather station for the analyzed area is located at an altitude of 534 m, at Ghimbav, and it belongs to the national network of meteorological stations of the National Meteorological Administration (ANM).

In order to relevantly outline the most hazardous climatic features of this important intra-mountainous area, the authors have opted for some of the WMO’s *Expert Team on Climate Change Detection and Indices* (ETCCDI) indices which, unlike the ”usual” weather and climatic indices generally being used to describe extreme events and phenomena, they mainly refer only to rare cases occurring ”within the reference statistical distribution of some specific weather elements in a certain area” (Houghton and colab., 2001), that is only to those specific climatic elements on which systematic and accurate daily measurements and observations are being made: air-temperature and rainfall amounts. Out of all the 27 ETCCDI indices best describing the main characteristics of some extreme weather and climatic events, such as their frequency, amplitude and duration, the following have been selected and calculated according to RClimDex or FClimDex methods, over the 1980-2015 period.

- **Frost days (FD)** – the total number of days in a year when the daily minimum air-temperature is lower than 0°C (TN< 0°C).
- **Maximum number of consecutive frost days (CFD)** – the longest period with consecutive frost days in which minimum air-temperature is lower than 0°C (TN< 0°C).
- **Cold spell duration index (CSDI) –** total number of intervals (number of days) comprising at least six consecutive days in which daily minimum air temperature (TN) is less than 10 percentiles (TN< 10 percentiles).
- **Heating degree-days (HDD)** – sum of all daily minimum air-temperatures lower than 0°C (HDDn0) and 10°C (HDDn10) respectively, out of all days within a period of reference.

As the period of reference (1980-2015) included homogenous data series, the respective ETCCDI indices were then processed in tabular and graphical form, mainly based on the corresponding daily minimum air-temperature values (TN) available for all months during the previously-mentioned period, so that a prospective time evolution trend could also be statistically indicated.

2. Results and discussions

The synoptic context most favorable for the occurrence of lowest minimum air temperatures in this area is the presence of an extensive anticyclone producing intense radiative cooling and strong temperature inversions. The lowest minimum air temperature that has ever been recorded over the above mentioned period in Brașov was -33.3°C, on 8th January 2015. The average of the corresponding lowest annual values was -5.8°C.

As showed in Table 1 presenting the lowest minimum air-temperature that have been recorded each year at the Brașov-Ghimbav weather station from 1980 to 2015, together with the exact day and month in which they had occurred, the most extreme values ranged between -33°C in 2015 (on 5th January) as the absolute lowest minimum value, and -17.6°C in 1994 (on 16th February and on 20th December), as the highest minimum value; with 13 absolute yearly minimum air-temperatures occurring in January, 12 in December and February respectively and a single one in March, out of all the 36 years taken into consideration. Though not scientifically customary, if calculating the average mean value of all these 36 yearly minimum air-temperatures, the result would be: -24.9°C, showing that extreme cold conditions could easily occur due to persistent winter thermal inversions in this intra-mountainous area.

Table 1. The lowest minimum air temperature of each year and the date of their production for the Brașov-Ghimbav meteorological station for the period 1980-2015. (Source: NMA archive for temperature values)

Year/Month	1980	Day	1981	Day	1982	Day	1983	Day	1984	Day	1985	Day	1986	Day	1987	Day	1988	Day	1989	Day
T (°C)	-27.5	14-Jan	-21.1	8-Jan	-23.6	11-Jan	-24.7	14-Dec	-23.5	13-Jan	-32.3	14-Jan	-20.0	27-Dec	-27.3	5-Mar	-23.8	2-Feb	-26.4	12-Dec
Year/Month	1990	Day	1991	Day	1992	Day	1993	Day	1994	Day	1995	Day	1996	Day	1997	Day	1998	Day	1999	Day
T (°C)	-29.2	5-Jan	-23.8	2-Feb	-23.4	23-Feb	-26.3	17-Feb	-17.6	16f/20d	-21.8	19-Jan	-23.5	27/28d	-21.5	18-Feb	-28.6	25-Dec	-20.8	2-Feb
Year/Month	2000	Day	2001	Day	2002	Day	2003	Day	2004	Day	2005	Day	2006	Day	2007	Day	2008	Day	2009	Day
T (°C)	-21.8	23-Jan	-28.2	18-Dec	-28.0	27-Dec	-23.7	23-Feb	-23.7	13-Feb	-31.6	6-Feb	-25.0	26-Jan	-19.5	19-Dec	-22.9	28-Dec	-24.2	4-Jan
Year/Month	2010	Day	2011	Day	2012	Day	2013	Day	2014	Day	2015	Day				Average	Minimum			
T (°C)	-30.2	25-Jan	-23.0	1-Feb	-26.5	2-Feb	-22.3	10-Jan	-25.2	31-Dec	-33.3	8-Jan				-24.9	-33.3			

The highest **number of frost days (FD)** is registered in January, with an average of 28 days for the entire period analyzed. From May to September, their average is less than 1 day, because all values (or almost all of them) are above 0°C.

The highest number of frost days resulted in 2011 (158 days) and the lowest in 2014 (104 days). The most relevant aspect is that the FD index shows a statistically significant decrease over time, from an average value of 140 days to almost 125 days (figure 2).

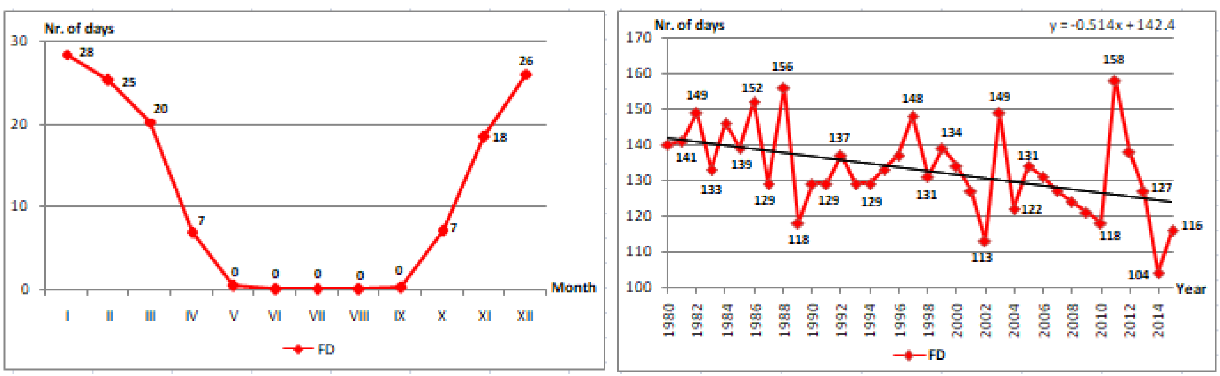

figure 2. The annual regime (left) and inter-annual variation (right) of the FD index for the period 1980-2015. (Source: NMA archive for temperature values)

The highest number of **consecutive frost days (CFD)** reached as high as 82 (at the beginning of 1982) and the lowest number is 16 days (in 1994). The trend of this index is not very statistically significant, decreasing from an average value of over 40 consecutive frost days to about 35 days in the 1980-2015 period.

Another interesting fact is that four cold waves occurring in 1986 and 2002 (Figure 3), resulted in maximum values of the **cold-spell duration index (CSDI)** at this meteorological station. This index represents the number of intervals per each year where, for at least six consecutive days, the daily minimum air temperature is lower than the calendar 10th percentile calculated for a 5-day window centered on each calendar day over the 1980-2015 period. Anyway, it is important to mention that there is at least one cold wave occurring each year, mainly due to the fact that the low-lying area of Brașov Depression greatly favors colder air to sink down to the feet of the surrounding mountains, thus producing very persistent and thick air-temperature inversions, responsible for more frequent cold-related weather phenomena.

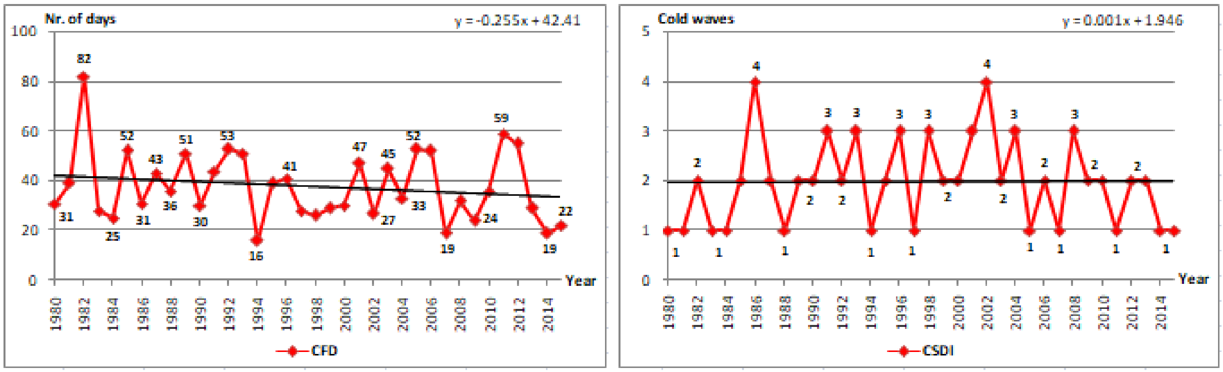

figure 3. The inter-annual variation of the CFD index (left) and the maximum values of the CSDI (right) for the period 1980-2015. (Source: NMA archive for temperature values)

The following indices (Figure 4) were also calculated to show the amount of energy required to heat homes. Obviously, the highest values were summed up in winter and the lowest in summer (in July, the HDDn10 index had a value of 0°C, which means that all the minimum air temperature values exceeded 10°C).

The inter-annual variation of heating degree days indices - **sum of all minimum temperature values less than 0°C (HDDn0)** and **sum of all minimum temperature values less than 10°C (HDDn10)** - shows that the coldest year was 1985 (with 1318.9°C for the HDDn0 index and with 3504.4°C for the HDDn10 index), and the warmest years were 2014 (with 521°C for HDDn0 index), respectively 2015 (with 2478.4°C for HDDn10 index).

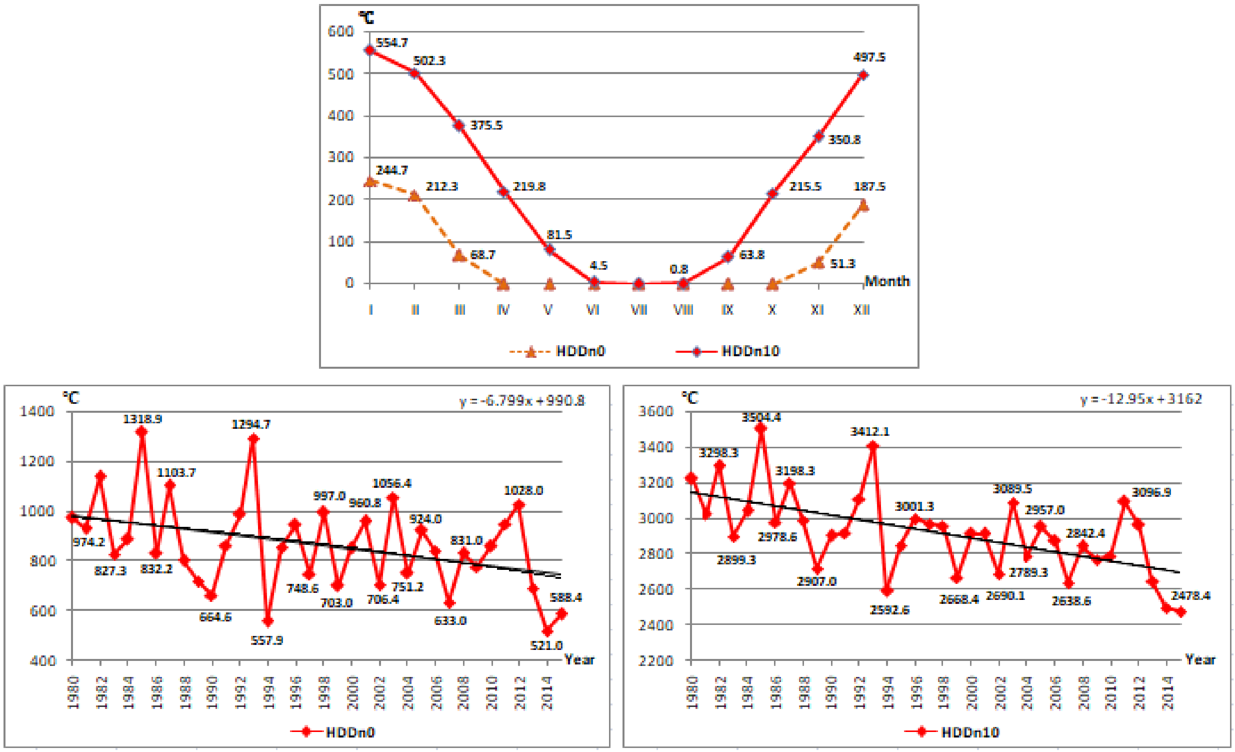

figure 4. The annual regime (above) and inter-annual variation of the HDDn0 index (left) and HDDn10 index (right) for the period 1980-2015. (Source: NMA archive for temperature values)

In both cases, it should be noted that these indices have decreased significantly over time, indicating a gradual increasing of the minimum temperatures over the period 1980-2015. The trend for HDDn0 index is decreasing from an average value of 1000°C to a value closer to 700°C, while the trend for HDDn10 index is decreasing more slowly from an average value around 3200°C to almost 2700°C, most probably due to the general ongoing climate warming process which largely attenuate the climatic cooling effects especially in winter.

Conclusion

The pretty high ranges of all these extreme values reveal not only that the general climatic conditions may quite often go to extremes, but also that there is a pretty high thermal variability from one month to another or from one year to another.

The late statement is also confirmed by all the indices calculated. The FD index tends to decrease rapidly in time (17 day in average over the 1980-2015 period), but there are also exceptions (158 frost days in 2011). The same thing happens to the CFD index, which is also decreasing in time. The CSDI index has a minimum value of one, which means at least one cold wave occurs each year in the analyzed area. The HDDn0 and HDDn10 indices reached record values in 1985 (1318.9°C for HDDn0 index and 3504.4°C for HDDn10 index), requiring high energy and fuel consumption. In contrast, the lowest values for these indices were calculated in 2014 and 2015 (HDDn0 index value less than 600°C and HDDn10 index value less than 2500°C), resulting in low values of energy and fuel demands.

The practical importance of all these quantitative assessments is given by the fact that they can be useful tools in calculating some important technical parameters which may be relevant for the design of heating or cooling installations, in order to maintain a comfortable indoor climate, without unnecessary energy waste. An important fact is that both the average value of these extreme indices and their duration in time must also be taken into account, and not only the values produced on a given day, on a specific month or year. By simply identifying the particularities of minimum air temperatures in the Brașov city may prove useful in the management of heat energy provided for domestic purposes.

The present study can be applied to other large cities in Romania, in order to find out the relationship between the amount of energy provided by power plants and the actual need for heating homes and for human comfort.

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