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Considerations regarding the evolution of extreme temperatures in the Banat Plain in the last six decades

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Abstract— During cold winter nights we often hear the question "where is the global warming, should it not be warmer?". Low temperatures that can still be recorded in the Banat Plain during winter or media reports of cold waves affecting various regions worldwide seem to the common man to be in total contradiction with the concerns of the scientific community about global warming. With this article we are trying to follow the evolution of some meteorological parameters that can affect the population in one way or another, namely number of tropical days, number of winter days, number of tropical nights, number of frosty nights, absolute maximum and minimum temperatures. Thus, the data obtained from the three national meteorological services (Romanian, Hungarian, and Serbian) operating on the territory of the Banat Plain were grouped in a common database and analyzed both in Excel and with the help of the non-parametric Mann-Kendall test, obtaining a series of conclusions on the evolution of the abovementioned parameters, as well as on the way how the increase in the risk of high temperatures is compensated (or not) by the decrease in the risk of low temperatures.

Key-words: tropical days, winter days, tropical nights, frosty nights, absolute maximum and minimum temperatures, Mann-Kendall test, Banat Plain

1. Introduction

Although climate change, including global warming, are normal phenomena caused by natural factors that climate scientists have been concerned about since the 19th century, the extent of these changes or the increasing global temperatures in the past decades and their increasing impact on human society have intensified the concerns of the international scientific community about the role of human society in amplifying climate change, its extent and evolution, the prevention or at least mitigation of its effects, etc. With this article, part of a larger, not yet completed work (*Dudaş* and *Urdea,* 2021), we want to contribute to the study of climate change over the last six decades and its effects at local level, focusing on the evolution of extreme temperatures, temperatures that can affect in one way or another the smooth running of human society. Numerous studies, taken not only at global level, but also at regional or local level (*Bartholy* and *Pongrácz*, 2007; *Gocić* and *Trajković*, 2012; *Cheval et al.*, 2014; *Gavrilov et al.*, 2016; *Lakatos et al.*, 2016; *Janković et al.*, 2019; *Papić et al.*, 2020*; Şmuleac et al.*, 2021; *Bačević et al.*, 2021; *Milentijević et al.*, 2022, etc), show us an increase in average temperatures in recent decades, which can also be observed from the data we have for the lowland Banat region (*Table 1*). Without denying the indirect effects of global warming on the area under investigation, we want to see how some of the climatic parameters that directly affect the population have evolved over the last six decades, namely those parameters related to high and low temperatures, and to see if it can be said that the increase in intensity of the hazards caused by high temperatures is compensated by the decrease in intensity of the hazards caused by low temperatures.

Table 1. Weather stations (operated by the Centrul Meteorologic Regional Banat-Crişana, Republički Hidrometeorološki Zavod Srbije, RHMZ, and Országos Meteorológiai Szolgálat, OMSZ), years of observation, and mean annual air temperatures used in the study

No.	Station name	Years of observation available	Mean annual air temperature (1961–1990) (°C)	Mean annual air temperature (1991–2020) (°C)
1.	Timişoara	1961–2020	10.6	11.7
2.	Arad	1961–2020	10.4	11.3
3.	Caransebeş	1961–2020	10.1	11.1
4.	Szeged	1901–2020	10.5	11.4
5.	Kikinda	1961–1985, 1991–2020	10.8	11.9
6.	Zrenjanin	1961–1985, 1991–2020	10.9	12.1
7.	Vršac	1961–1985, 1991–2020	11.4	12.4

In a historical sense, the Banat region can be defined as the region bounded on the north by the river Mureş, on the south by the Danube, on the west by the Tisza, which extends east to the border with Transylvania and Wallachia, being currently divided between 3 states: Romania, Serbia, and Hungary (*Fig. 1*). Located in the southeastern part of the Pannonian Plain (Nagyalföld or Alföld), the Banat Plain occupies the western part of the Banat region, in the east, the boundary to the Banat Hills and Mountains being approximately given by the contour lines ranging from 160 m to 200 m, on a sinuous line between Lipova and the area where the Nera flows into the Danube (*Posea*, 1997) (*Fig. 1*). The altitudinal distribution of the Banat Plain brings out the existence of a higher level, near the hills and mountains and a lower level, with young and less developed landforms, the boundary between the two types of plain generally following the contour line of 100 m (*Ianoş et al.*, 1997) (*Fig. 1*).

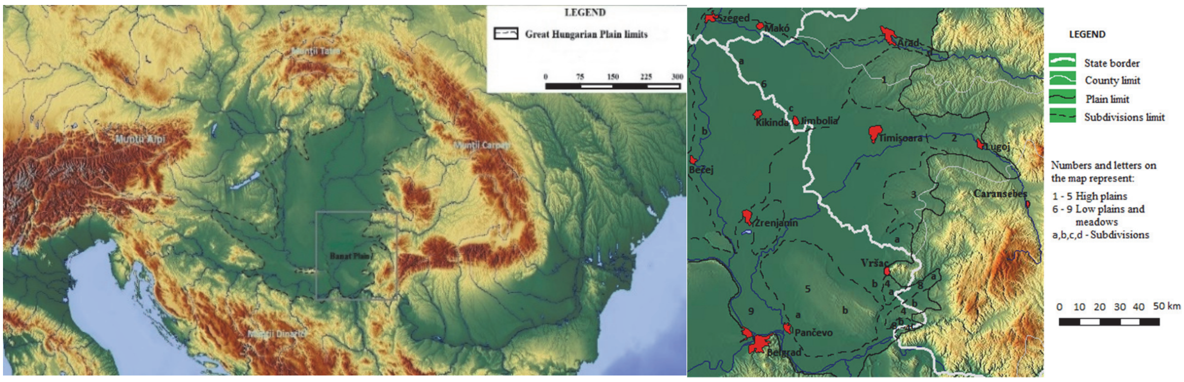

Fig. 1. The location of the Banat Plain within the Pannonian Basin, boundaries and subdivisions (adaptation after various sources).

The geographic location of the Banat Plain, along with the general movement of the atmosphere, determines the existence of a moderate temperate continental climate. Even if we can talk about a certain homogeneity of the main climatic elements all across the studied area, there are small differences with regard to the micro- and topoclimate, differences caused by the natural environment elements or anthropic influence. Calculated for the last 60 years (1961–2020), the multiannual mean temperature value in the Banat Plain is in the range of 10.5–12 °C, increasing by about one degree in the second half of the period (*Table 1*), while the average annual rainfall in the Banat Plain for the same period is generally between 500–700 mm (Centrul Meteorologic Regional Banat - Crişana, Republički Hidrometeorološki Zavod Srbije, RHMZ, Országos Meteorológiai Szolgálat, OMSZ).

2. Database and methodology

The first known meteorological measurements were made in the Banat Plain between 1780 and 1803 by Carl Josef Klapka in Timișoara (*Réthly,* 1918, 1970). Although measurements were made during the entire 19th century in various localities in the lowland Banat, the sporadic nature of these measurements, as well as their accuracy according to current standards, led us not to mention them during this work. The lack of meteorological parameters or the incomplete data strings we have from different meteorological stations for the 20th century have also limited our options quite a lot regarding the period and the meteorological stations investigated. Finally, we chose seven meteorological stations, Timişoara, Kikinda, Zrenjanin, and Vršac being located within the limits of the Banat Plain, while Arad, Szeged, and Caransebeș are located slightly outside the limits of the investigated area, north of the river Mureş, respectively, west of the Tisza or in the Caransebeș depression, an extension of the plain within the mountainous area (*Fig. 1*).

For the years 1986–1990 we are still missing data from Kikinda, Zrenjanin, and Vršac, but we consider that these missings do not affect the image of the evolution trends and the final conclusions.

Given that the aim of this work is to follow the evolution of temperature-related hazards, the following six parameters were chosen:

- number of tropical days (Td) or number of hot days – days when the maximum temperature is ≥ 30 °C;
- number of winter days (Wd) or ice days – days when the maximum temperature is ≤ 0° C;
- number of tropical nights (Tn) – days with a minimum temperature ≥ 20 °C;
- number of frosty nights (Fn) or number of severe cold days – days with a minimum temperature ≤ -10 °C;
- absolute highs – the highest temperature in a month/year;
- absolute lows – the lowest temperature in a month/year.

Even if not all six parameters fall entirely into the category of phenomena defined as hazards (potentially damaging phenomena), it cannot be denied the discomfort they create and the expense of reducing this discomfort.

The completion of this article involved several stages:

a. Collecting the necessary data and creating a small database in Excel. Data for the Romanian meteorological stations were purchased from the Regional Meteorological Center of Banat – Crișana (Centrul Meteorologic Regional Banat – Crișana), data for the Szeged weather station are available online at the Hungarian Meteorological Service (Országos Meteorológiai Szolgálat) website (https://www.met.hu), while data for Serbian weather stations were taken from the Meteorological Yearbooks of the Federal Hydrometeorological Institute of Yugoslavia/Republican Hydrometeorological Service of Serbia (Republički Hidrometeorološki Zavod Srbije), also available online (https://www.hidmet.gov.rs/index.php).

b. Observing and verifying the data to avoid discrepancies between the data from a given station and the data from other stations for a given parameter in a given year or between different parameters from the same weather station for a given year; obtaining average values for the Banat Plain for all parameters.

c. Making graphs and obtaining the trend equation using linear regression for all parameters, both for monthly and annual trends. Trend equation was calculated by Excel with the formula $y = ax+b$, where y represents the parameter in a given year, a is the slope, x is the time in years, and b is the parameter at the beginning of the period. Easy to perform and interpret, there are three possible scenarios: if $a \geq 0$, the trend is positive, increasing, if $a = 0$, there is no trend, and if $a \leq 0$ the trend is negative, decreasing (*Gavrilov et al.*, 2016).

d. Applying the Mann-Kendall non-parametric test for all parameters to confirm the presence of trends in both monthly and annual values. Under MK test, two hypotheses have been tested: the null hypothesis, H_o, indicating no trend in the time series; and the alternative hypothesis, H_a, indicating that there is a significant trend in the time series for a given level of significance. The probability, p, has been calculated in percents to determine the level of confidence in the hypothesis. When the p value calculated is less than the assumed significance level a (e.g., a=5%), the H_o hypothesis has to be rejected (no trend) and the Ha (there is a significant trend) should be accepted. If p is higher than significance level a, the H_o hypothesis (no trend) cannot be rejected (*Gavrilov et al.*, 2016).
XLSTAT software (http://www.xlstat.com/en) has been used to calculate the probability and hypothesis testing.

e. Performing arithmetic operations between existing parameters, from the evolution of the resulting parameters (Td+Wd, Tn+Fn, Td-Wd, Tn-Fn, absolute thermal amplitudes) being able to better observe the increasing or decreasing trends of the thermal risk, as well as the climate evolution trends.

3. Results

As mentioned earlier, we will paint an image of the evolution trends for extreme temperatures in the Banat Plain through several climate parameters.

3.1. *Tropical days*

Tropical days (Td) may occur in the Banat Plain starting from April until October, their average for the interval 1961–2020 is 32 days/year, with higher values at Timişoara, Zrenjanin, Arad, Vršac, or Kikinda and lower in Szeged and Caransebeş. The lowest average value was recorded in 1978, 5.7 days/year, and the highest in 2012, 72.3 days/year, and in terms of the absolute minimum, it was recorded in 1977 at Caransebeş, 2 days/year, and the absolute maximum in 2012 at Zrenjanin, 78 days/year (*Table 2*).

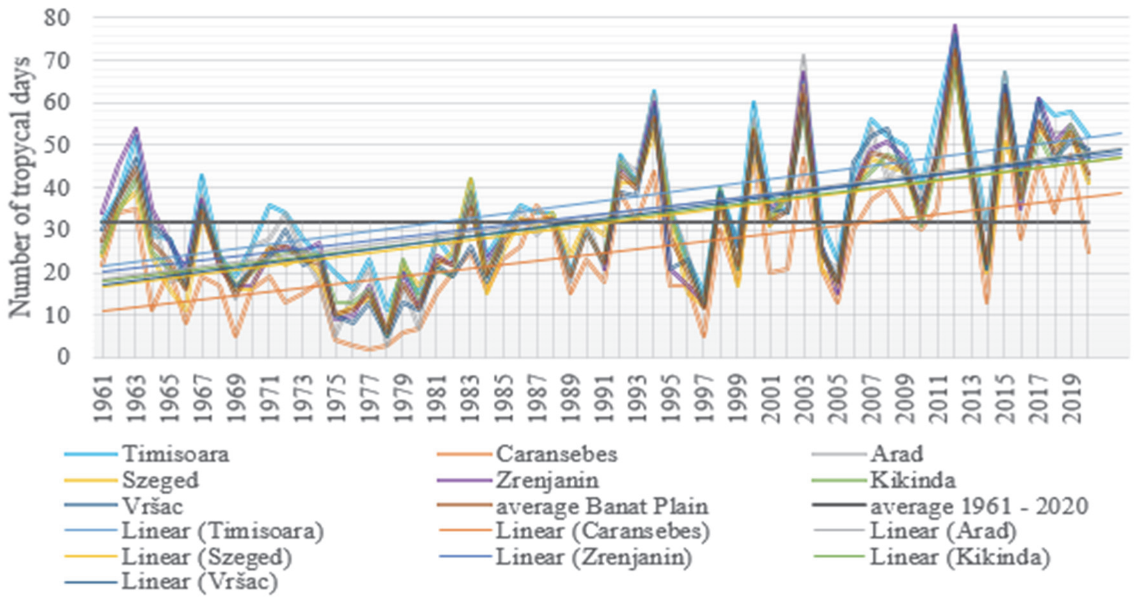

Fig. 2. Evolution of the annual number of tropical days at the analyzed meteorological stations.

Table 2. Evolution of the annual number of tropical days in the Banat Plain analyzed by Mann-Kendall trend tests

Station name	Trend equation	Min.	Max.	Mean	Std. deviation	Kendall 's tau	p-value	Sen's slope
Timişoara	y=0.5127x+20.996	11	76	36.633	15.362	0.379	<0.0001	0.500
Caransebeş	y=0.4592x+10.462	2	70	24.467	14.509	0.377	<0.0001	0.455
Arad	y=0.5078x+18.012	3	71	33.500	15.534	0.401	<0.0001	0.488
Szeged	y=0.4980x+16.077	7	71	31.267	14.483	0.418	<0.0001	0.529
Zrenjanin	y=0.4538x+19.838	6	78	33.782	16.566	0.313	0.001	0.457
Kikinda	y=0.4727x+17.731	5	68	32.255	14.513	0.367	<0.0001	0.455
Vršac	y=0.5142x+16.854	5	76	32.655	16.198	0.362	0.000	0.500
average Banat Plain	y=0.4884x+17.056	5.714	72.286	31.953	14.723	0.376	<0.0001	0.479

An evolution over time of this indicator for the last 6 decades (*Fig. 2*) reveals us values generally below average for the first three decades, with small exceedances of the average values during seven years in the 1960s and 1980s and values below average in 23 years, the longest period with below average values being between 1968 and 1982. In the last three decades, there is a predominance of above-average values, values that exceed by 50% the multiannual average being registered in 1994, 2000, 2003, 2007, 2012, 2015, and 2017–2019. Over the decades, there is a decrease in values in the 1970s, compared to the 1960s, followed by a steady increase to the present day.

The Mann-Kendal trend test confirms the general growth trend of this parameter, both at the level of the Banat Plain and at the level of each analyzed meteorological station (*Table 2*).

Concerning the monthly distribution of this parameter (*Fig. 3*), in the Banat Plain there can be tropical days starting from April, but their number is very low, with a total of 21 cases, all in the last 3 decades and with a peak in 2013, when there were 1–2 cases for each weather station analyzed. The Mann-Kendal trend test confirms the existence of a trend, but the Sen's slope is 0 (*Table 3*). In May, the average number of tropical days for the whole Banat Plain has been 1.18 days/month for the last six decades, with relatively uniformly distributed values, except for the 8th decade of the last century, with 0.5 days/month and the 1st decade of our century, with 2.6 days, giving the slightly increasing trend of this parameter. In 22 years there have been no tropical days at all in the Banat Plain in May. Half of the cases were recorded in the last two decades of the interval, while the maximum number of tropical days, 9.9, was recorded in 2003. The Mann-Kendal trend test confirms the existence of a trend, but with a very small slope (*Table 3*).

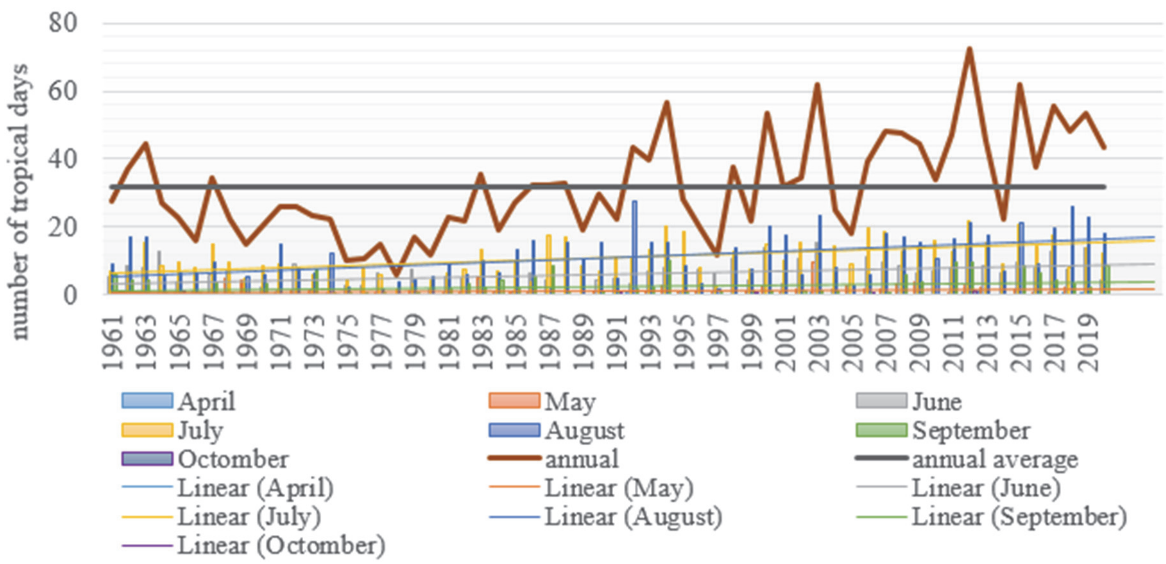

Fig. 3. Evolution of the monthly number of tropical days in the Banat Plain.

Table 3. Evolution of the monthly number of tropical days in the Banat Plain analyzed by Mann-Kendall trend tests

Month	Trend equation	Min.	Max.	Mean	Std. deviation	Kendall's tau	p-value	Sen's slope
April	y=0.0035x-0.0571	0	1.429	0.050	0.210	0.297	0.005	0
May	y=0.0178x+0.6393	0	9.857	1.182	1.766	0.191	0.040	0.006
June	y=0.0965x+3.0554	0	15.429	5.998	4.057	0.277	0.002	0.099
July	y=0.1456x+6.5737	1.857	21.857	11.013	4.913	0.343	<0.0001	0.143
August	y=0.1876x+5.4510	0	27.714	11.171	6.908	0.339	<0.0001	0.199
September	y=0.0372x+1.3539	0	10.429	2.488	2.987	0.089	0.326	0.011
Octomber	y=0.0003x+0.0395	0	1	0.050	0.197	0.059	0.584	0

For June, the average of 6 tropical days/month is exceeded in the early 1960s growing steadily since the second half of the 1990s. Zero tropical days were recorded in June 1978, 1988, and 1989, and the maximum, 15.4 tropical days, in June 2003. The Mann-Kendal trend test confirms the existence of a trend, with a significant slope (*Table 3*). For July, the average of 11 tropical days/month is exceeded twice in the 1960s and three times in the 1980s, then consistently since 1990, with the maximum number of tropical days in July being 21.9 days in 2012 and the minimum 1.9 days in 1978. A very large difference also occurs between the number of tropical days recorded in July in the 8th decade of the last century, 59.7, and the number of tropical days recorded in the last decade, 146.6. The Mann-Kendal trend test confirms the existence of a trend, with a significant slope (*Table 3*). August shows the strongest upward trend in the number of tropical days, exceeding the number of tropical days in July in the second part of the period. This trend is best illustrated by the difference between the number of tropical days recorded in the 8th decade of the last century, 5.94/month, and the number of days recorded in the last decade, 17.91/month. The average is 11.2 tropical days/month, but the values vary widely, from 0 days in 1968 or 1976 to 27.7 days in 1992. The Mann-Kendal trend test confirms the existence of a trend, with a significant slope (*Table 3*).

For the month of September, the average of 2.5 tropical days/month is exceeded especially in the last decade, when the average was 5.3, with this decade actually dictating the upward trend of this indicator. However, the record number of tropical days in September was recorded in 1994, 10.4, while months with no tropical days were in 13 cases. The Mann-Kendal trend test does not confirm the existence of a trend (*Table 3*). In October, as in April, we have a number of 21 cases registered in the Banat Plain in the last 60 years, most of them in 1965 and 2012, then in 2006, 1991, and 1999; these are missing from Szeged, where the last tropical day in October was recorded in 1942. Same as for September, the Mann-Kendal trend test does not confirm the existence of a trend (*Table 3*).

3.2. Winter days

The average number of winter days (Wd) for the Banat Plain over the last six decades has been 19.72 days/year, higher in Szeged, Arad, and Kikinda and lower in Zrenjanin, Caransebeş, Timişoara, and Vršac. The graph of the evolution over time of this indicator in the Banat Plain (*Fig. 4*) shows several periods with a high number of winter days between 1962 and 1969, with a maximum of 47.1 days/year in the Banat Plain and an absolute maximum of 57 winter days/year in Szeged, both in 1963, then 1985–1993, 2002–2005, and 2009–2012, alternating with periods when the number is below average, such as 1972–1975, with a minimum of 3 winter days/year in the Banat Plain and an absolute minimum of 2 days/year in Timişoara, Caransebeş, and Vršac, both in 1974, then in 2006–2008, and 2013–2020.

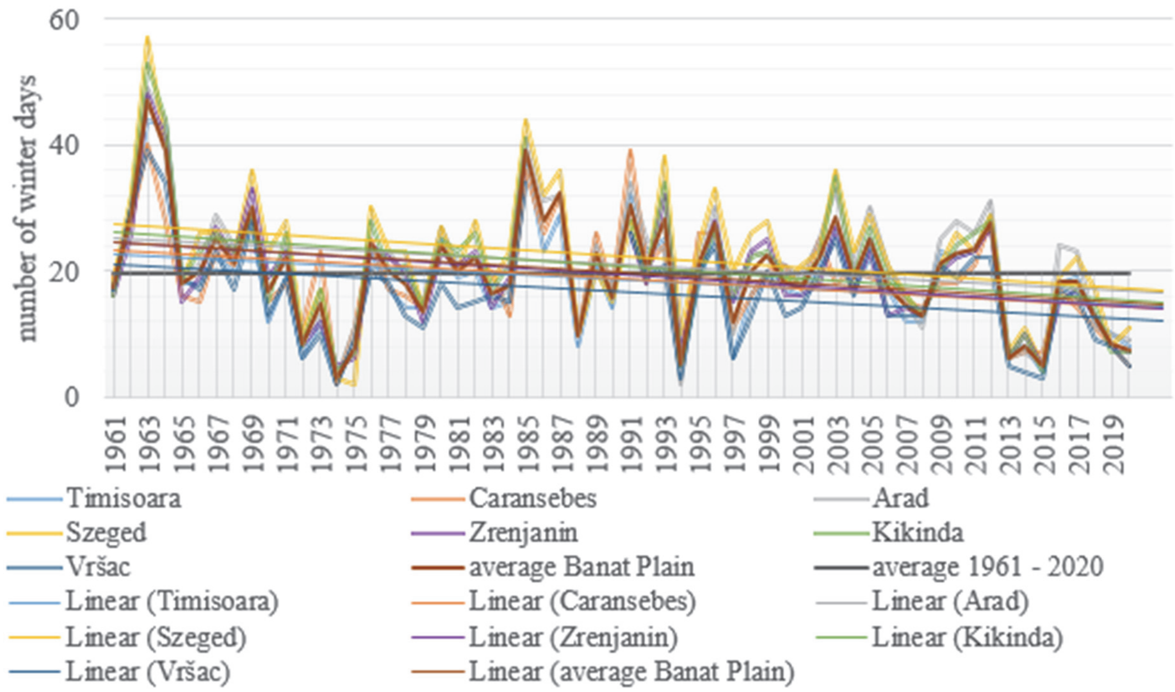

Fig. 4. Evolution of the annual number of winter days at the analyzed meteorological stations.

If we analyze this parameter by decades, we notice a very high number of winter days in the 1960s, 26.4/year, followed by a low number of winter days in the 1970s, 15.6/year, again a high number of winter days in the 1980s, 22.3/year, decreasing until the last decade, when an average of 13.5 winter days/year are recorded. The very high number of cases in the 1960s, correlated with the low number of winter days recorded in the last decade, determines the downward trend of this parameter at all meteorological station analyzed (*Fig. 4*).

The Mann-Kendal trend test confirms the decreasing trend of this parameter for the Banat Plain and also for Caransebeș, Szeged, Zrenjanin, Kikinda, and Vršac, while for Timișoara and Arad the existence of a trend is not confirmed (*Table 4*).

Table 4. Evolution of the annual number of winter days in the Banat Plain analyzed by Mann-Kendall trend tests

Station name	Trend equation	Min.	Max.	Mean	Std. deviation	Kendall's tau	p-value	Sen's slope
Timişoara	y=-0.1358x+22.609	2	44	18.467	8.771	-0.141	0.117	-0.104
Caransebeş	y=-0.1533x+23.527	2	40	18.850	8.038	-0.235	0.009	-0.157
Arad	y=-0.1404x+25.383	2	49	21.100	9.628	-0.113	0.206	-0.108
Szeged	y=-0.1721x+27.667	2	57	22.417	10.187	-0.187	0.037	-0.158
Zrenjanin	y=-0.1730x+24.605	5	48	19.291	8.954	-0.233	0.013	-0.174
Kikinda	y=-0.1814x+26.264	4	53	20.691	9.739	-0.229	0.015	-0.163
Vršac	y=-0.1461x+21.072	2	39	16.582	8.078	-0.189	0.045	-0.125
average Banat Plain	y=-0.1589x+24.575	3	47.143	19.728	8.731	-0.186	0.036	-0.138

Winter days may occur in the Banat Plain from November until March. In November, the average number of winter days for the Banat Plain ranges from 0 days in most years to 4 – 5 days in 1978, 1988, and 1993, the average for the whole range being 0.6 winter days/month. The trend is slightly downward, with low values in the first and last two decades analyzed and higher values in the 8th - 10th decades, with a maximum of 1.2 days in the last decade of the 20th century and a minimum of 0.1 days in the first decade of the 21st century (*Fig. 5*). The Mann-Kendal trend test does not confirm the existence of a trend (*Table 5*). In December, we have a maximum number of winter days in the 1960s, 8.1, followed by a decrease in the number of days in the 1970s, when, although the absolute maximum of 16.4 days is reached in 1977, the average for the whole decade is 4.9 days, thenit is followed by an increase to 7 days/month in the first decade of the 21st century, and again a decrease to 3.3 days in the last decade. The average of this parameter for the whole interval is 5.8 winter days/month, with a downward trend. The minimum of 0.14 days/month is reached in 1979, 1985, and 2020, years in which only one winter day was recorded at one of the stations analyzed (in 1979 at Caransebeș, in 1985 and 2020 at Szeged) (*Fig. 5*). The Mann-Kendal trend test does not confirm the existence of a trend (*Table 5*).

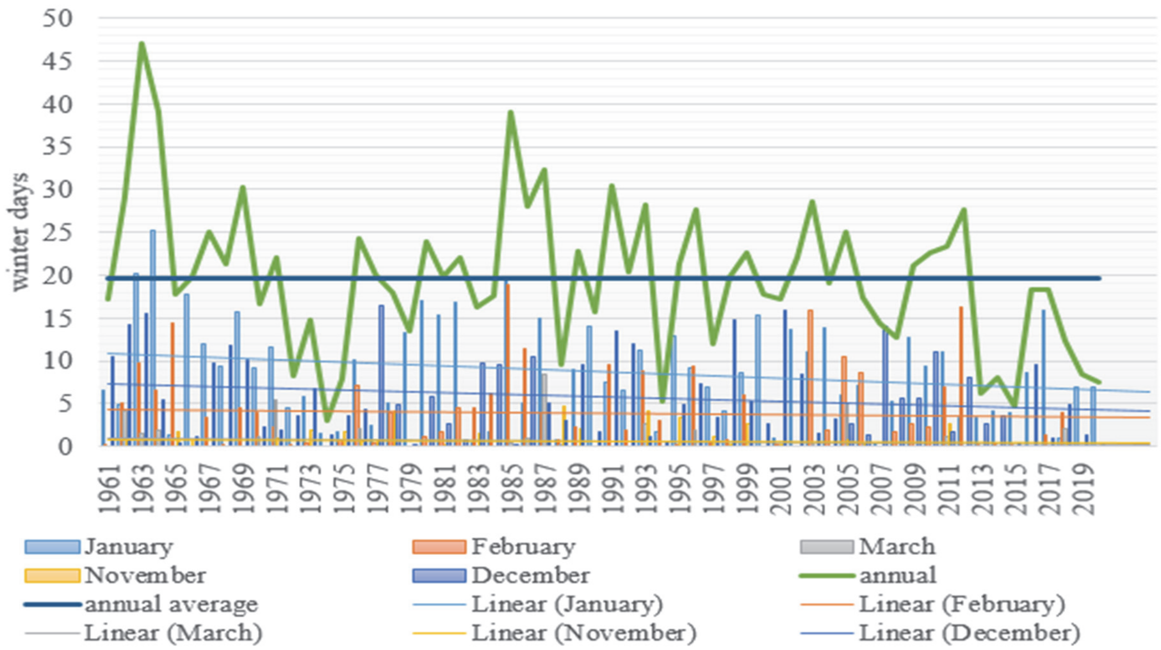

Fig. 5. Evolution of the monthly number of winter days in the Banat Plain.

Table 5. Evolution of the monthly number of winter days in the Banat Plain analyzed by Mann-Kendall trend tests

Month	**Trend equation**	**Min.**	**Max.**	**Mean**	**Std. deviation**	**Kendall's tau**	**p-value**	**Sen's slope**
January	y=-0.0717x+10.913	0.429	25.286	8.724	5.808	-0.129	0.146	-0.064
February	y=-0.0172x+4.309	0	18.857	3.866	4.659	-0.094	0.297	-0.011
March	y=-0.0129x+1.0583	0	8.500	0.665	1.587	-0.123	0.221	0
November	y=-0.0066x+0.8288	0	4.750	0.627	1.165	-0.089	0.363	0
December	y=-0.0505x+7.3853	0.143	16.429	5.846	4.746	-0.124	0.164	-0.039

In January, the month with the most winter days, the evolution over the last 6 decades is very similar to the annual evolution of this parameter, with the most winter days recorded in the first decade of observation, 12.2 days, and the fewest in the last, 6.6 days, with the absolute maximum in 1964 and the absolute minimum in 1983 and 2007. Although the graph shows a downward trend, the Mann-Kendal trend test does not confirm the existence of a trend (*Table 5*). In February, this parameter oscillates between above-average values in decades 9, 7, 1, and 10 and below-average values in decades 8 and 2, with the maximum number of winter days in the 1980s, 5.4 days, and the fewest in the 1970s, 1.6, with the absolute maximum reached in 1985 and the absolute minimum of 0 days reached in 10 of the 60 years (*Fig. 5*). The Mann-Kendal trend test does not confirm the existence of a trend (*Table 5*). In March, although there were no winter days in most years, the average for the whole interval is 0.7 days/month, with a predominance in the first half of the interval, a maximum of 1 day/month in the 1980s and a minimum of 0.3 days/month in the last decade, an absolute maximum in March 1987, and a downward trend (*Fig. 5*). The Mann-Kendal trend test does not confirm the existence of a trend (*Table 5*).

A representation of the two climatic parameters, tropical days (Td) and winter days (Wd), on the same graph (*Fig. 6*) can lead us to a few intermediate conclusions on the evolution of climate risks over the last 6 decades in the Banat Plain:

The decrease in the sum and consequently in the average (Td+Wd and (Td+Wd)/2) in the 1970s compared to the 1960s and then the steady increase of these two indicators until today shows a decrease in extreme temperature risk in the 1970s, a decade that has been the safest in terms of extreme temperature risk for the past 60 years, and then a steady increase until today, with the last decade being the most exposed to extreme temperature risk, with a total of 62.2 days/year, compared to 32.4 days/year in the 1970s; the absolute minimum of 18 days/year in total was in 1975 and the absolute maximum of 100 days was in 2012. The Mann-Kendal trend test confirms the existence of an increasing trend (*Table 6*).

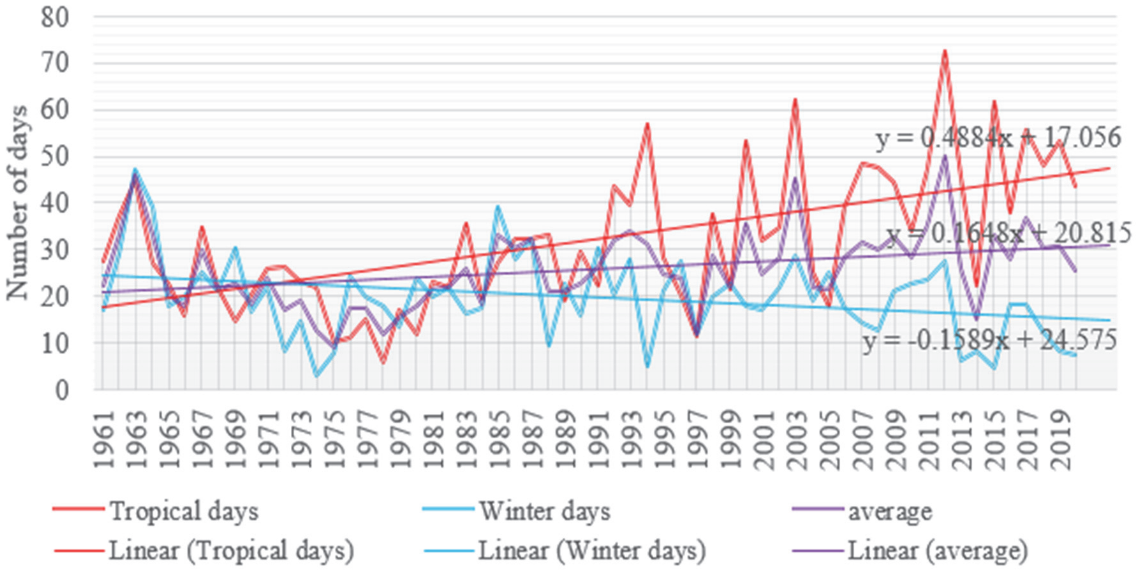

Fig. 6. Evolution of the annual number of tropical and winter days in the Banat Plain.

Table 6. Evolution of the annual number of tropical and winter days in the Banat Plain analyzed by Mann-Kendall trend tests

Parameter	**Min.**	**Max.**	**Mean**	**Std. deviation**	**Kendall's tau**	**p-value**	**Sen's slope**
Tropical days Td	5.714	72.286	31.953	14.723	0.376	<0.0001	0.479
Winter days Wd	3	47.143	19.728	8.731	-0.186	0.036	-0.138
average (Td+Wd)/2	9	50	25.840	8.282	0.273	0.002	0.185
sum Td+Wd	18	100	51.681	16.564	0.273	0.002	0.370
diference Td-Wd	-15.429	57	12.225	17.653	0.433	<0.0001	0.617

The increase in the average difference between the number of tropical days and the number of winter days (Td-Wd), from 0.3 days/year in the 1960s to 35.2 days/year in the last decade, and the decrease in the number of years with negative values of this parameter, from 3 to 4 years/decade in the last century to only one year in the last two decades, indicate a pronounced increase in the risk of high temperatures compared to the risk of low temperatures. The Mann-Kendal trend test also confirms the existence of an increasing trend (*Table 6*).

3.3. Tropical nights

The average number of tropical nights (Tn) for the Banat Plain over the last six decades has been 4.4 days/year, higher in Vršac and Zrenjanin and lower in Kikinda, Timişoara, Arad, Caransebeş and Szeged; the weather station of Vršac stands out in particular, with values well above the annual average of the Banat Plain in all 60 years, values below the multiannual average being recorded only in 5 years, in the first half of the interval (*Fig. 7*). An evolution over time of this indicator at the level of the entire Banat Plain shows values below average in 27 of the 30 years in the first half of the interval, the only years in which more than 4.4 tropical nights/year were recorded are 1963, 1987, and 1988, and values are shown above average in 24 of the 30 years in the second half of the interval; the highest value was recorded in 2015, 16.4 tropical nights on average for the Banat Plain. Also, if we relate these values to decades, we observe a decrease in the number of tropical nights in the 70s, compared to the 60s, then there is a constant increase until today, when, in the last decade, 8.4 tropical nights/year were recorded. The trend, clearly increasing, shows different values for the analyzed stations, being more accentuated in Zrenjanin and Vršac and less accentuated in Szeged and Caransebeș. The Mann-Kendal trend test confirms the general growth trend of this parameter, both at the level of the Banat Plain and at the level of each analyzed meteorological station (*Table 7*).

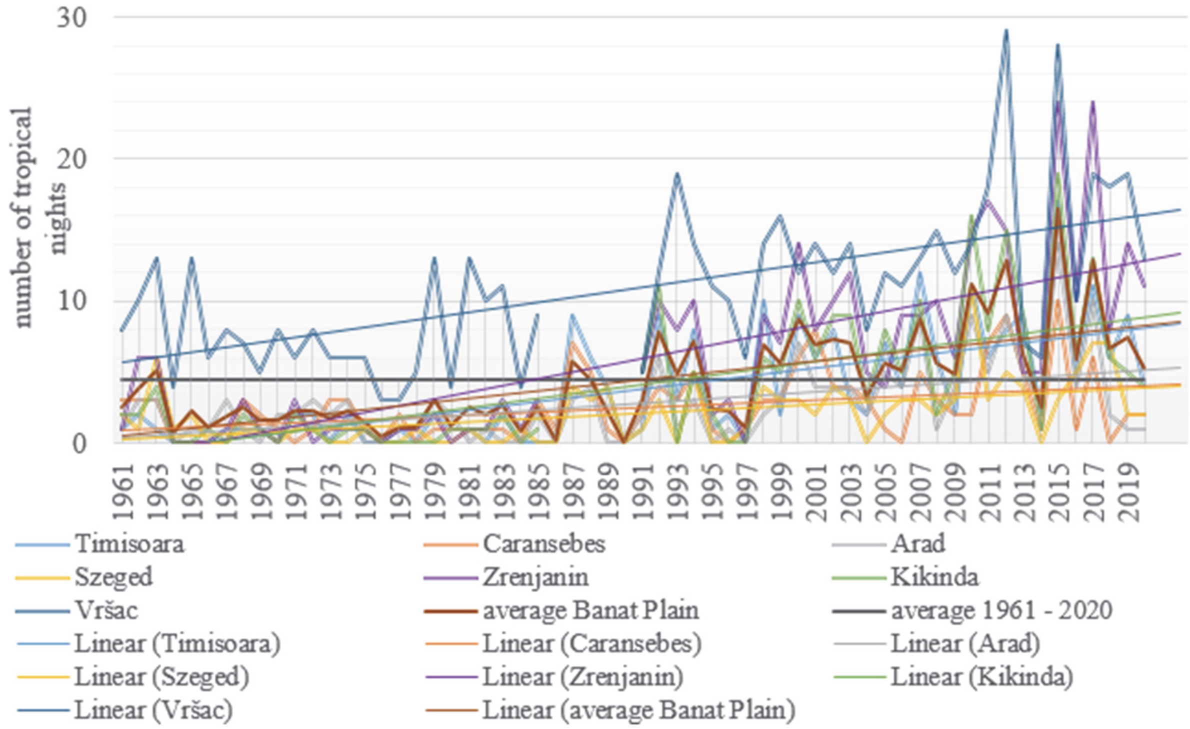

Fig. 7. Evolution of the annual number of tropical nights at the analyzed meteorological stations.

Table 7. Evolution of the annual number of tropical nights in the Banat Plain analyzed by Mann-Kendall trend tests

Station name	Trend equation	Min.	Max.	Mean	Std. deviation	Kendall's tau	p-value	Sen's slope
Timişoara	y=0.1492x-0.8508	0	17	3.700	3.959	0.491	<0.0001	0.114
Caransebeş	y=0.0531x+0.8814	0	10	2.500	2.397	0.257	0.0060	0.034
Arad	y=0.0817x+0.2910	0	14	2.783	2.865	0.338	0	0.055
Szeged	y=0.0621x+0.1384	0	11	2.033	2.224	0.344	0	0.048
Zrenjanin	y=0.2368x-1.3475	0	24	5.927	5.912	0.576	<0.0001	0.200
Kikinda	y=0.1638x-0.9228	0	19	4.109	4.609	0.454	<0.0001	0.121
Vršac	y=0.1767x+5.4784	3	29	10.909	5.545	0.398	<0.0001	0.160
average Banat Plain	y=0.1329x+0.3533	0	16.429	4.408	3.441	0.469	<0.0001	0.109

Although, theoretically, tropical nights can occur in the Banat Plain from April onwards, in the last 60 years they have been accidental, with only 2 cases recorded, both in Vršac, in 1975 and 2018. In May, the average number of tropical nights of the last 6 decades for the entire Banat Plain was 0.13 days per month, 84% of the cases being recorded in Vršac, 9% in Caransebeş, 5% in Zrenjanin and one case in Timișoara, with higher values in the 7th and 10th decades of the 20th century and the 1st decade of the 21st century and lower values in the 8th and 9th decades of the last century, as well as in the last decade. In 29 years there were no tropical days recorded at all in the Banat Plain in May, while the maximum number of tropical nights, 6 cases/7 stations, was recorded in 1968. The Mann-Kendal trend test does not confirm the existence of a trend in these two months (*Table 8*).

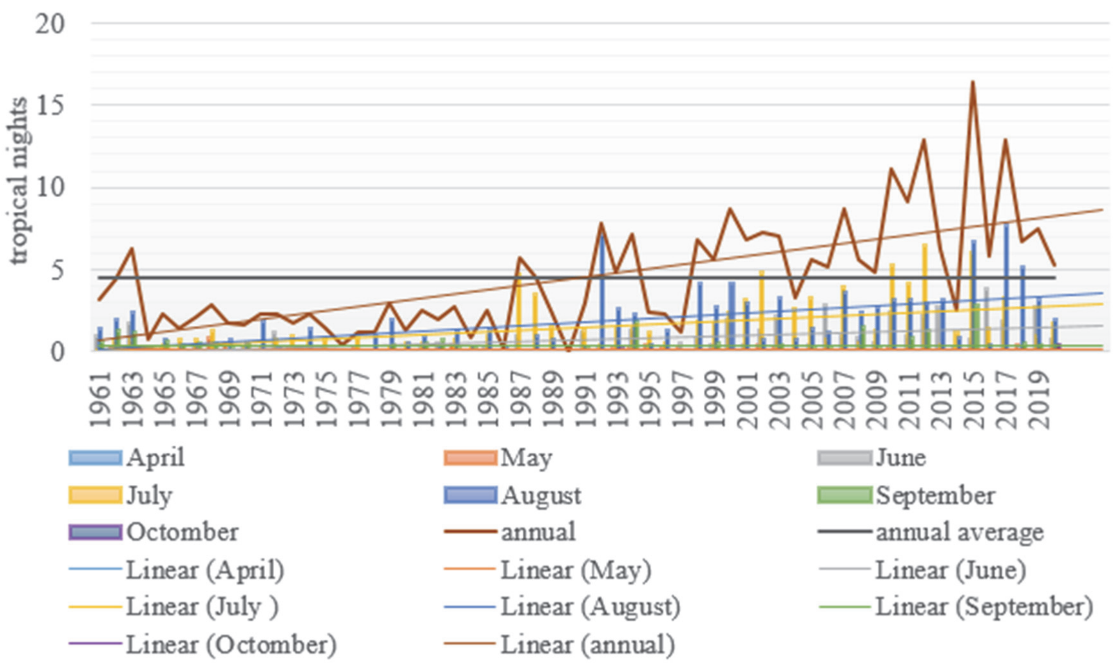

Fig. 8. Evolution of the monthly number of tropical nights in the Banat Plain.

Table 8. Evolution of the monthly number of tropical nights in the Banat Plain analyzed by Mann-Kendall trend tests

Month	**Trend equation**	**Min.**	**Max.**	**Mean**	**Std. deviation**	**Kendall's tau**	**p-value**	**Sen's slope**
April	y=0.0001x+0.0019	0	0.143	0.005	0.026	0.053	0.621	0
May	y=-0.0005x+0.1488	0	0.857	0.133	0.174	0.025	0.804	0
June	y=0.0258x-0.0493	0	3.857	0.738	0.880	0.356	0	0.015
July	y=0.0456x+0.0683	0	6.429	1.460	1.591	0.369	<0.0001	0.029
August	y=0.0550x+0.06410	0	7.714	1.740	1.794	0.377	<0.0001	0.042
September	y=0.0016x+0.3165	0	2.857	0.365	0.528	-0.100	0.290	0
October	y=0.0006x-0.00008	0	0.429	0.019	0.072	0.057	0.593	0

The number of tropical nights in June, continuously increasing since the 1980s, went from 0.2 nights/month in the 8th-9th decades to 1.6 nights/month in the last decade, the average over the last 6 decades was 0.7 nights/month; the maximum was recorded in 2016, 3.86 nights/month, while 0 cases were recorded 10 times. For July, the average of 1.5 tropical nights/month is exceeded for the first time in 1987 growing steadily since 1998, reaching 2.7 tropical nights/month in the first decade of the 21st century, with a slight decrease in the second decade; 0 days were recorded in four years, and the maximum occurred in 2012. August has the maximum number of tropical nights per month, an average of 1.7, with lower and decreasing values in the first 3 decades, a minimum in the 1980s, when the number of tropical nights is higher (double) in July, there is a pronounced increase in the 1990s, when the number of tropical nights in August is double compared to July, a further decrease and predominance of tropical nights in July occur for the first decade of the current century and an increase in the last decade. The Mann-Kendal trend test confirms the existence of an upward trend in these three months (*Fig. 8, Table 8*).

In September, we have an average of 0.36 tropical nights/month, with the highest values occurring in the first and last of the 6 decades observed, and the lowest in the 1970s and 1980s, September being the only month in which the trend of this parameter is not increasing; the high number of tropical nights in the last decade is mainly due to the high number of tropical nights recorded in 2015, 7 in Vršac, 6 in Zrenjanin, 4 in Caransebeş, and 1 in Timişoara, Arad, and Kikinda. For the month of October, it is more unusual to record tropical nights, in the last 60 years there have been 8 cases in 5 years, 7 cases in Vršac and one in Zrenjanin, with a peak in 2020, when there were two cases in Vršac and one in Zrenjanin. The Mann-Kendal trend test does not confirm the existence of a trend in these two months (*Table 8*).

3.4. Frosty nights

The average number of frosty nights (Fn) over the last six decades for the Banat Plain has been 9 nights/year, higher in Arad, Szeged, or Vršac and lower in Timişoara, Kikinda, Caransebeş, and Zrenjanin. The time evolution graph (*Fig. 9*) shows an alternation of periods with a high number of frosty nights with periods in which the number of frosty nights is much below average, with a maximum in the 1960s, when the average number at the Banat Plain level was 14 nights/year, followed by a decrease to 7.3 nights/year in the 1970s and again an increase to 10.7 nights/year in the 1980s. In the last 3 decades, although this alternation continues, the annual average of frosty nights is lower than the average for the last 6 decades, the trend of evolution of this parameter being visibly decreasing; in the last decade there was an average of 5.2 frosty nights/year in the Banat Plain. Minimum annual values of this parameter were recorded in 1974, when only Vršac recorded one frosty night, and 2007, when Szeged recorded one frosty night, the average on the Banat Plain in both cases was 0.14, while maximum annual values were in 1985, with 31.9 frosty nights and 1963, with 30.1. The Mann-Kendal trend test confirms the general decreasing trend of this parameter, both at the level of the Banat Plain and at the level of each analyzed meteorological station (*Table 9*).

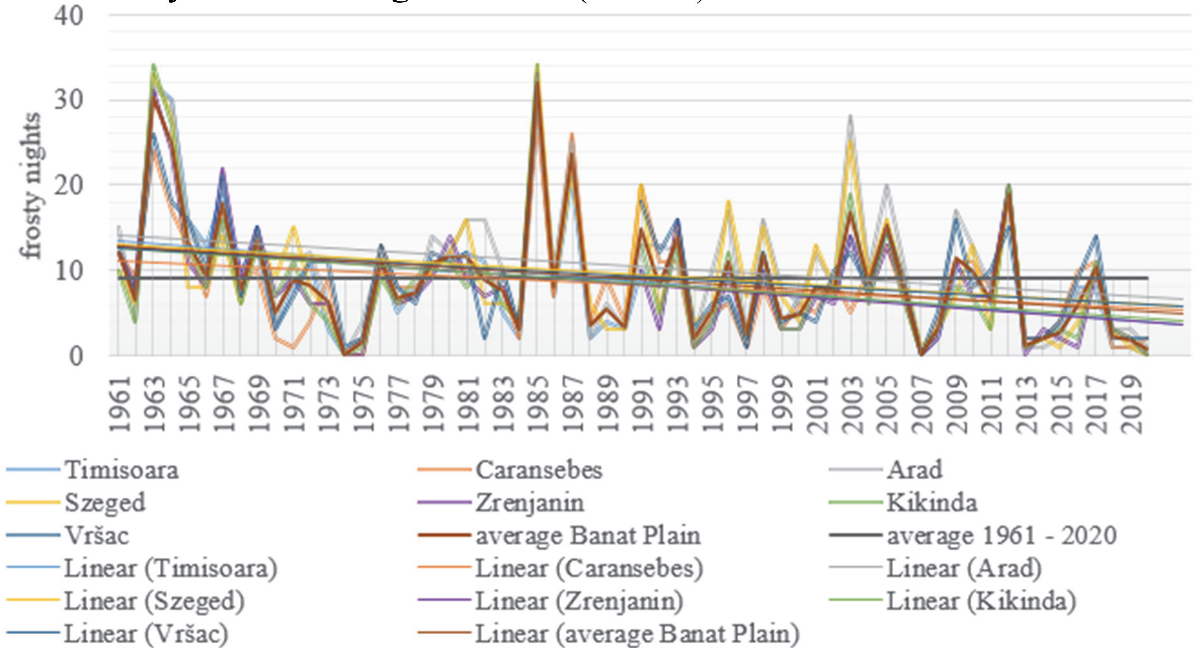

Fig. 9. Evolution of the annual number of frosty nights at the analyzed meteorological stations.

Table 9. Evolution of the annual number of frosty nights in the Banat Plain analyzed by Mann-Kendall trend tests

Station name	Trend equation	Min.	Max.	Mean	Std. deviation	Kendall's tau	p-value	Sen's slope
Timişoara	y=-0.1612x+13.584	0	32	8.667	7.201	-0.293	0.001	-0.125
Caransebeş	y=-0.0957x+11.269	0	28	8.350	6.257	-0.191	0.035	-0.098
Arad	y=-0.1232x+14.275	0	32	10.517	7.769	-0.197	0.029	-0.106
Szeged	y=-0.1193x+13.072	0	34	9.433	7.758	-0.220	0.015	-0.111
Zrenjanin	y=-0.1519x+13.013	0	33	8.345	7.170	-0.293	0.002	-0.13
Kikinda	y=-0.1375x+12.644	0	34	8.418	7.440	-0.275	0.004	-0.114
Vršac	y=-0.1133x+12.737	0	32	9.255	6.513	-0.221	0.020	-0.100
average Banat Plain	y=-0.1294x+12.948	0.143	31.857	9.001	6.813	-0.236	0.008	-0.118

Frosty nights can be expected in the Banat Plain from November until March. In November, the average number of days with frosty nights for the Banat Plain ranges from 0 days in the majority of years to 2.6 days in 1983, the average for the whole period is 0.2 frosty nights/month. The trend is slightly downward, most of the frosty nights were recorded in the first half of the interval, then three years with frosty nights in the interval 1993–1995, and there is only one record for the last 2 decades, in 2005, in Arad. In December, we have an average of 2 days with frosty nights/month, highlighting the period between 1998–2002, when the absolute maximum is recorded, 10.8 frosty nights/month in 1998, followed by the years 2003–2008 and 2013–2020, with values well below average, reaching 0 frosty nights/month in 2003, 2004, 2013, 2017, 2019 and 2020, the latter determining the downward trend of the entire interval. The Mann-Kendal trend test confirms the existence of a trend only for November, but with a zero slope (*Fig. 10, Table 10*).

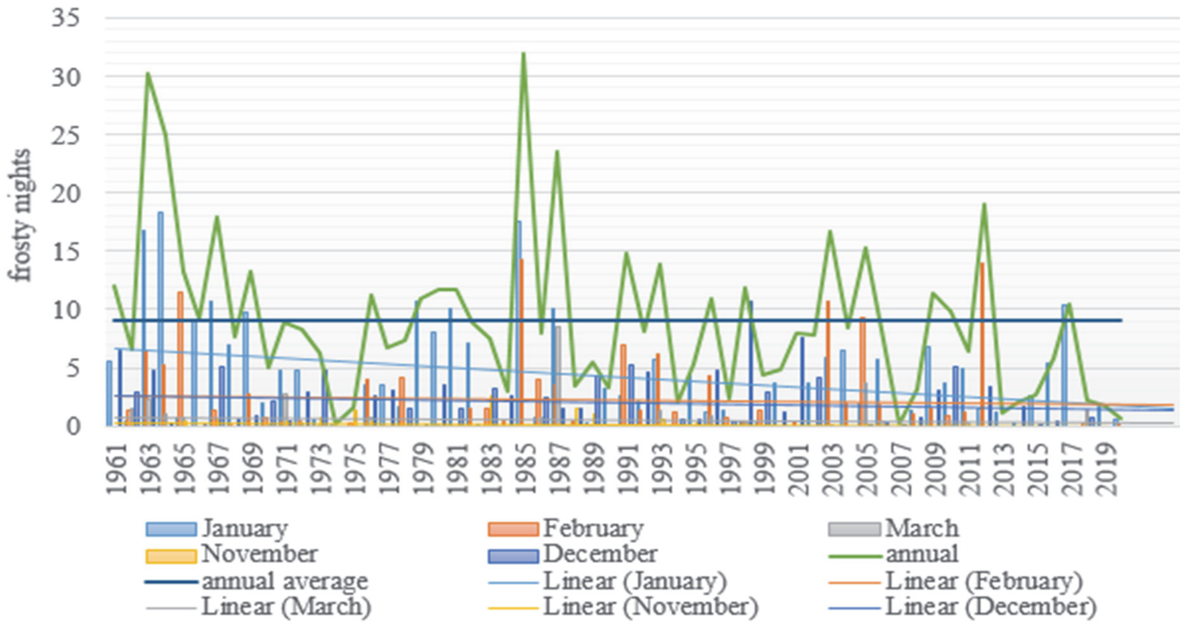

Fig. 10. Evolution of the monthly number of frosty nights in the Banat Plain.

Table 10. Evolution of the monthly number of frosty nights in the Banat Plain analyzed by Mann-Kendall trend tests

Month	Trend equation	Min.	Max.	Mean	Std. deviation	Kendall's tau	p-value	Sen's slope
January	y=-0.0827x+6.7469	0	18.286	4.226	4.498	-0.158	0.077	-0.044
February	y=-0.0129x+2.5658	0	14.286	2.174	3.495	-0.105	0.255	0
March	y=-0.0081x+0.7076	0	8.500	0.461	1.275	-0.163	0.100	0
November	y=-0.0055x+0.3400	0	2.571	0.173	0.444	-0.237	0.020	0

December	y=-0.0203x+2.5877	0	10.714	1.967	2.278	-0.155	0.089	-0.012

In January, the month with the most frosty nights, the evolution over the last 6 decades is similar to the annual evolution of this parameter, with the most frosty nights recorded in the first decade of observation, 8, except that the fewest frosty nights, 2.2, were recorded in the 1990s; the absolute maximum was in 1964 and the absolute minimum in 1975, 1983, 1984, 1988, 2001, 2007, and 2011, with 0 days. The strongly decreasing trend visible on the graph is not confirmed by the Mann-Kendal trend test (*Fig. 10, Table 10*).

In February, this parameter oscillates between values above the average of 2.2 frosty nights in the 7th, 1st, and 9th decades, 2.2 frosty nights in the 10th decade and values below this average in the 8th and 2nd decades, with the highest number of frosty nights in the 1960s, 3 nights on average, and the fewest in the 1970s, 0. 9, with the absolute maximum reached in 1985, 14.3 frosty nights, and the absolute minimum of 0 frosty nights reached in 20 of these 60 years. The trend, which is not very downward, leads to December being overtaken by February for this parameter, although in the first half of the period analyzed, the situation was the opposite. In March, although in most years there were no frosty nights, the average for the whole interval is 0.5 days/month, with 1987 standing out with 8.5 frosty nights and with a downward trend. The Mann-Kendal trend test does not confirm the existence of a trend in these two months (*Table 10*).

Combining again two opposite parameters, tropical nights (Tn) and frosty nights (Fn), on the same graph (*Fig. 11*), we can find some intermediate conclusions about the evolution of climate risks in the last 6 decades in the Banat Plain:

The sharp decrease in the sum and mean (Tn+Fn and (Tn+Fn)/2) from maximum values in the 1960s to minimum values in the 1970s, then a slow increase until a decade ago, and again a decrease in the last decade are mainly due to the evolution of the number of cold nights. The decrease in the last decade was unable to be compensated by the increase in the number of tropical nights. Again, the 1970s can be considered the safest in terms of extreme temperature risk for the past 60 years, with an average Tn+Fn sum of 9 days/year and a minimum sum of 2.4 days in 1974. The 1960s were the most exposed to extreme temperature risk with an average Tn+Fn sum of 16.3 days/year and a maximum of 35.3 days in 1963 (*Fig. 11, Table 11*). The Mann-Kendal trend test does not confirm the existence of a trend for any of the two parameters (*Table 11*).

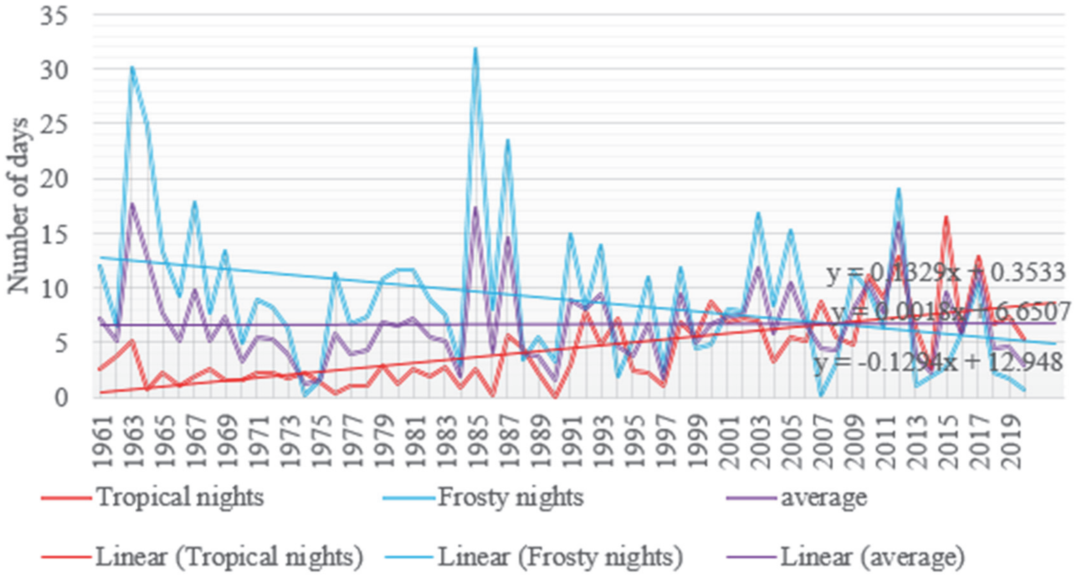

Fig. 11. Evolution of the annual number of tropical and frosty nights in the Banat Plain.

Table 11. Evolution of the annual number of tropical and frosty nights in the Banat Plain analyzed by Mann-Kendall trend tests

Parameter	**Min.**	**Max.**	**Mean**	**Std. deviation**	**Kendall's tau**	**p-value**	**Sen's slope**
Tropical nights Tn	0	16.429	4.408	3.441	0.469	<0.0001	0.109
Frosty nights Fn	0.143	31.857	9.001	6.813	-0.236	0.008	-0.118
average (Tn+Fn)/2	1.214	17.643	6.704	3.725	0.019	0.833	0.008
sum Tn+Fn	2.429	35.286	13.408	7.450	0.019	0.833	0.017
diference Tn-Fn	-29.286	13.714	-4.593	7.811	0.440	<0.0001	0.238

The difference between the two parameters (Tn-Fn) also decreases very quickly in the 1970s (-5.6 nights/year) compared to the 1960s (-11.6 nights/year), increases in the 1980s due to the increase in the number of frosty nights, then decreases again until today, when it reaches positive values (3.3 nights/year); the minimum of -29.3 is recorded in 1985, and the maximum of 13.7 in 2015. It is also worth mentioning that while in the first half of the period, this parameter had positive values only in two years, 1974 and 1988, in the last decade only one negative value was recorded, in 2012. The Mann-Kendal trend test also confirms the existence of an increasing trend (*Table 11*).

3.5. Absolute maximum temperature

The absolute maximum temperature measured in the Banat Plain for the period 1961–2020 was 42.9 °C, recorded on July 24, 2007 in Zrenjanin, at the same date as the absolute maximums measured were for Vršac, 42.2 °C, Timişoara, 41.1 °C, Caransebeş, 40.3 °C, and Kikinda, 40 °C, after the absolute maximum temperature of 39.8 °C had been recorded two days earlier for Szeged; in Arad, the absolute maximum of 40.8 °C was recorded on July 23, 2017. From the data available to us, we can state that 2007 and 2017 were the only years out of the last 60 in which temperatures above 40 °C were recorded, with the average annual maximum for the Banat Plain exceeding 40 °C in 2007; annual maximums above 39 °C were also recorded in 2000, 2012, 1988, and 1961. As for the lower values of the annual maximums in the Banat Plain, it can be seen that an annual maximum below 35 °C has not been recorded since 1997, while such values were recorded quite frequently in the 7th–8th decades. The trends in the evolution of maximum temperatures are positive, the graph shows a more marked increase for the weather station of Szeged, the only station where the absolute maximum for the last 60 years does not reach 40 °C, and a more moderate increase for Timişoara, the station with the highest average annual maximum, and for Caransebeş, the station with the lowest average annual maximum. The Mann-Kendal trend test confirms the existence of an increasing trend for all weather stations except Caransebeş (*Fig. 12, Table 12*).

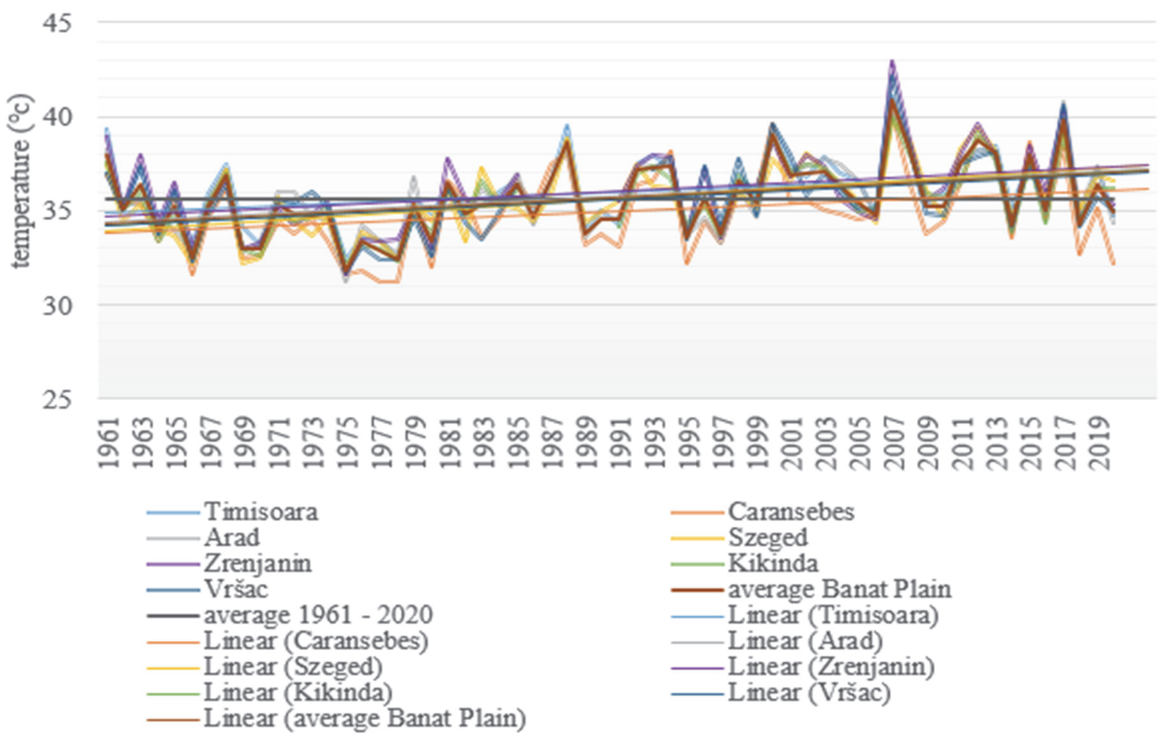

Fig. 12. Evolution of the annual maximum temperatures at the analyzed meteorological stations.

Table 12. Evolution of the annual maximum temperatures in the Banat Plain analyzed by Mann-Kendall trend tests

Station name	Trend equation	Min.	Max.	Mean	Std. deviation	Kendall's tau	p-value	Sen's slope
Timişoara	y=0.0372x+34.862	32.4	41.1	35.997	1.908	0.227	0.011	0.040
Caransebeş	y=0.0375x+33.812	31.2	40.3	34.957	2.165	0.166	0.062	0.031
Arad	y=0.0467x+34.345	31.2	40.8	35.768	2.004	0.272	0.002	0.047
Szeged	y=0.0587x+33.798	31.7	39.8	35.588	1.912	0.375	<0.0001	0.058
Zrenjanin	y=0.0457x+34.593	31.6	42.9	35.996	2.152	0.265	0.005	0.042
Kikinda	y=0.0483x+34.099	32.1	40.0	35.584	1.859	0.308	0.001	0.050
Vršac	y=0.0465x+34.188	31.7	42.2	35.617	2.149	0.229	0.015	0.042

3.6. Absolute minimum temperature

The absolute minimum temperature measured in the Banat Plain for the period 1961–2020 was -35.3 °C recorded on January 24, 1963 in Timișoara. On the same day being recorded the absolute minimums were -32.6 °C, for Vršac, -30.4 °C in Zrenjanin, -29.8 °C in Kikinda, and -29.8 °C Arad, while the next day was recorded the absolute minimum for Caransebeș, -26.8 °C; in Szeged the absolute minimum of -27.8 °C was recorded on January 31, 1987. From the data available to us, we can state that 1963 was the only year in the last 60 in which temperatures below -30 °C were recorded and the only year when the average annual minimum for the Banat Plain reached -30 °C; annual average minimum below -25 °C was also recorded in 1987. The only years when average lows did not fall below -10 °C were 1974, 2007, and 2020. The evolution trends of minimum temperatures are positive, the graph showing a more pronounced increase for the weather stations of Timişoara and Vršac, the latter being the station with the lowest average annual minimum, but the Mann-Kendal trend test does not confirm the existence of any trend for any of the studied weather stations (*Fig. 13, Table 13*).

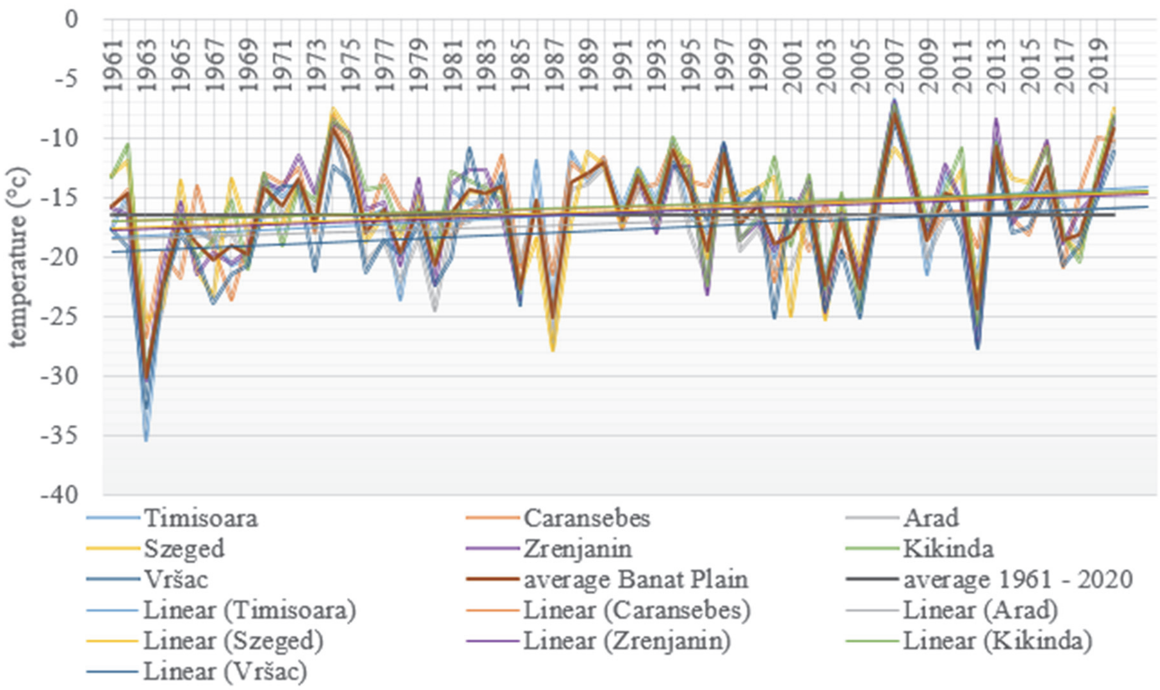

Fig. 13. Evolution of the annual minimum temperatures at the analyzed meteorological stations.

Table 13. Evolution of the annual minimum temperatures in the Banat Plain analyzed by Mann-Kendall trend tests

Station name	Trend equation	Min.	Max.	Mean	Std. deviation	Kendall's tau	p-value	Sen's slope
Timişoara	y=0.0696x-18.357	-35.3	-6.7	-16.233	4.555	0.132	0.139	0.048
Caransebeş	y=0.0384x-16.995	-26.8	-7.7	-15.823	3.865	0.095	0.284	0.034
Arad	y=0.0445x-18.523	-29.8	-7.7	-17.165	4.383	0.103	0.248	0.035
Szeged	y=0.0485x-17.569	-27.8	-7.5	-16.090	4.515	0.146	0.101	0.053
Zrenjanin	y=0.0488x-17.714	-30.4	-6.9	-16.215	4.780	0.124	0.182	0.054
Kikinda	y=0.0430x-17.041	-29.8	-7.2	-15.720	4.697	0.118	0.206	0.047
Vršac	y=0.0617x-19.638	-32.6	-8.6	-17.743	4.682	0.165	0.078	0.064

The monthly absolute maximum (*Fig. 14*) and minimum (*Fig. 15*) temperatures show an upward trend, with more pronounced increases in general in the winter and summer months and more moderate in the spring and autumn months. These trends are generally in line with the general evolution of temperatures in the Banat Plain. The Mann-Kendal trend test confirms the existence of an increasing trend for monthly maximum temperatures in February, June, July, August, and December, as well as for monthly minimum temperatures in July, August, September, and December (*Table 14*).

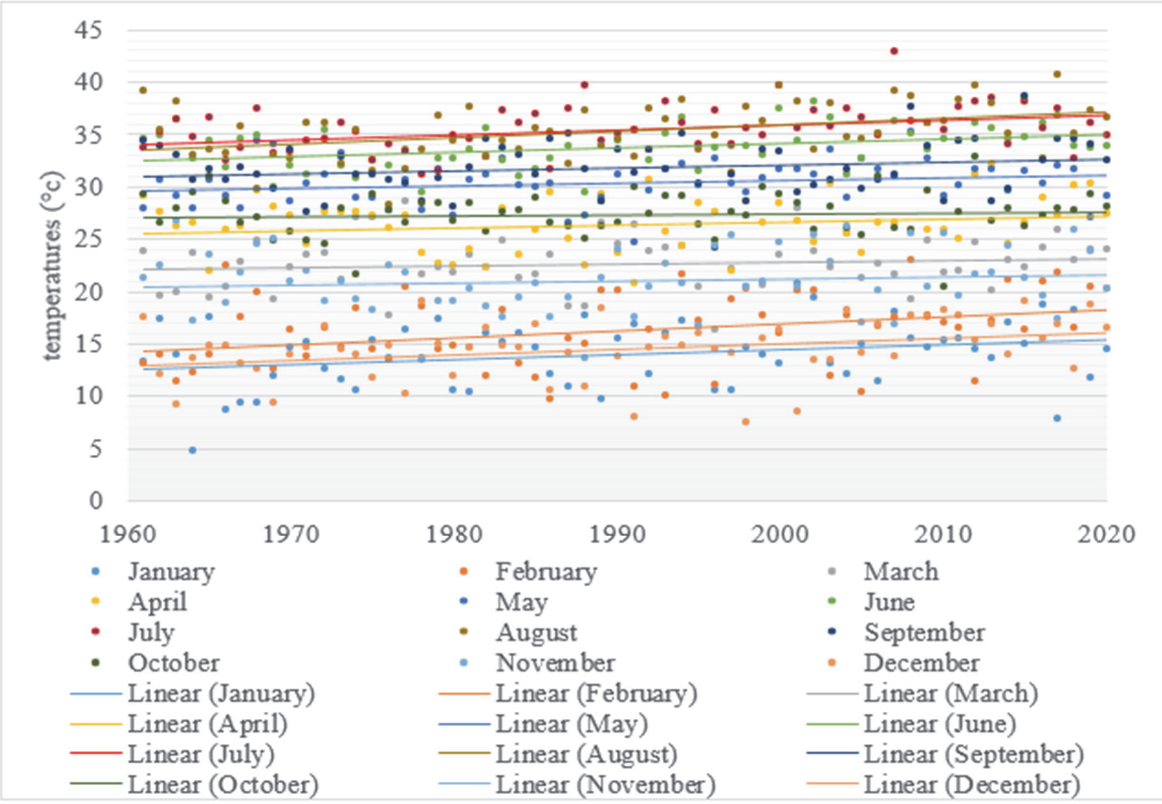

Fig. 14. Evolution of the monthly absolute maximum temperatures in the Banat Plain.

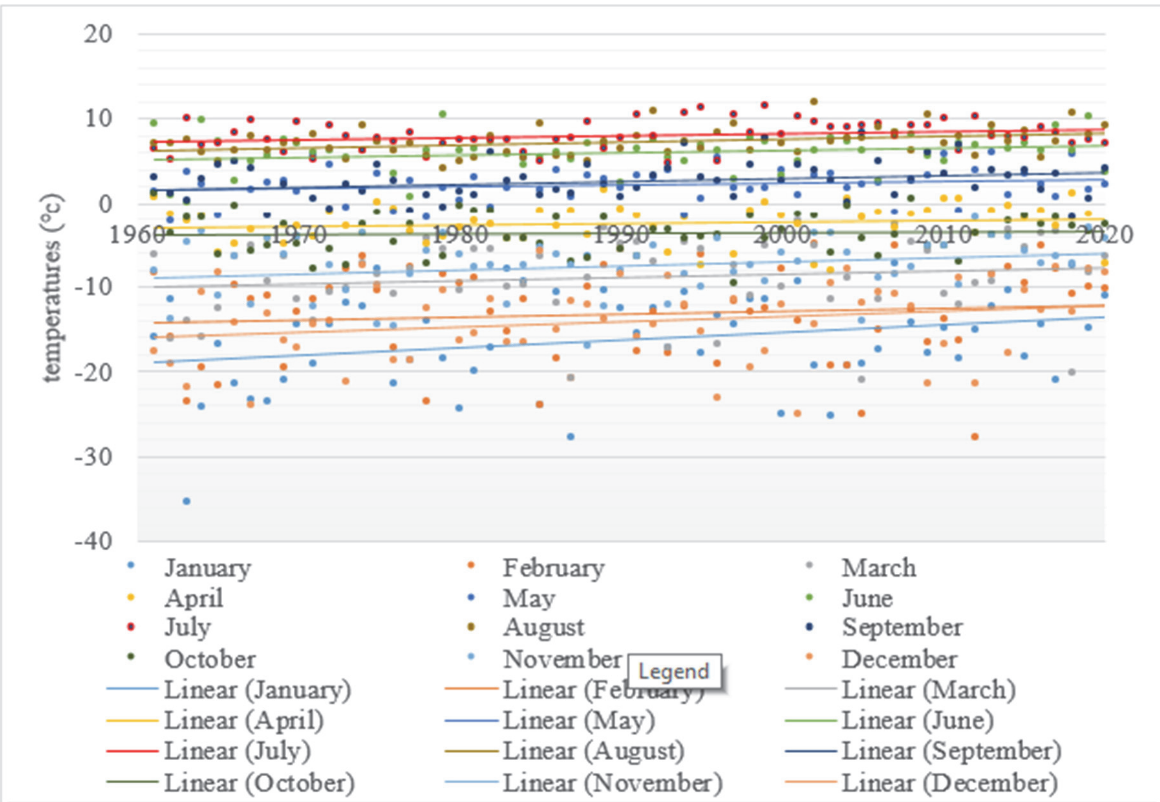

Fig. 15. Evolution of the monthly absolute minimum temperatures in the Banat Plain.

Table 14. Evolution of the monthly absolute maximum and minimum temperatures in the Banat Plain analyzed by Mann-Kendall trend tests

Month	Max/ min	Trend equation	Min	Max	Mean	Std. deviation	Kendall's tau	p-value	Sen's slope
January	max	y=0.0467x-78.985	4.8	20.7	13.99	3.093	0.163	0.068	0.050
	min	y=0.0878x-190.87	-35.3	-6.6	-16.19	5.754	0.151	0.09	0.084
February	max	y=0.0653x-113.66	9.6	23.1	16.28	3.52	0.227	0.011	0.072
	min	y=0.0376x-88.079	-27.7	-4.9	-13.19	5.593	0.083	0.352	0.039
March	max	y=0.0166x-10.435	16.2	28.6	22.68	2.544	0.103	0.246	0.021
	min	y=0.0377x-84.005	-21.0	-2.3	-8.92	4.540	0.155	0.082	0.052
April	max	y=0.0279x-29.044	20.7	32.2	26.44	2.551	0.087	0.329	0.024
	min	y=0.0188x-40.015	-8.1	1.6	-2.58	2.274	0.143	0.109	0.030
May	max	y=0.0239x-17.281	24.8	35.2	30.36	2.028	0.165	0.065	0.028
	min	y=0.0201x-37.801	-2.3	6.0	2.22	2.025	0.112	0.209	0.016
June	max	y=0.0413x-48.564	28.6	38.1	33.70	2.048	0.247	0.006	0.042
	min	y=0.0258x-45.413	0	10.5	6.03	2.163	0.130	0.146	0.019
July	max	y=0.0481x-60.311	31.1	42.9	35.53	2.173	0.281	0.002	0.047
	min	y=0.0262x-44.177	4.6	11.5	8.00	1.661	0.182	0.042	0.027
August	max	y=0.0620x-87.977	28.3	40.8	35.35	2.605	0.292	0.001	0.065
	min	y=0.0340x-60.398	4.3	11.8	7.22	1.610	0.252	0.005	0.033
September	max	y=0.0268x-21.450	24.1	38.6	31.8	2.541	0.098	0.272	0.02
	min	y=0.0366x-70.220	-4.2	8.5	2.59	2.364	0.176	0.048	0.038
October	max	y=0.0075x+12.482	20.4	32.8	27.36	2.058	0.039	0.664	0.006
	min	y=0.0059x-15.568	-9.5	1.2	-3.74	2.314	0.059	0.511	0.013
November	max	y=0.0189x-16.652	13.4	26.8	20.99	3.007	0.069	0.436	0.018
	min	y=0.0496x-106.29	-17.0	-1.8	-7.55	3.353	0.158	0.075	0.047
December	max	y=0.0534x-91.853	7.5	19.1	14.50	2.769	0.250	0.005	0.059
	min	y=0.0627x-138.72	-24.9	-5.7	-13.99	4.607	0.186	0.036	0.080

The absolute annual thermal amplitudes, for the Banat Plain as well as for the analyzed meteorological stations (*Fig.16*), show important oscillations from one year to another, with values above average especially in the 1960s and 2000s and below average in the 1970s, 1980s, and 1990s, but we cannot speak about the existence of a trend, which is also visible from the Mann-Kendall trend test (*Table 15*).

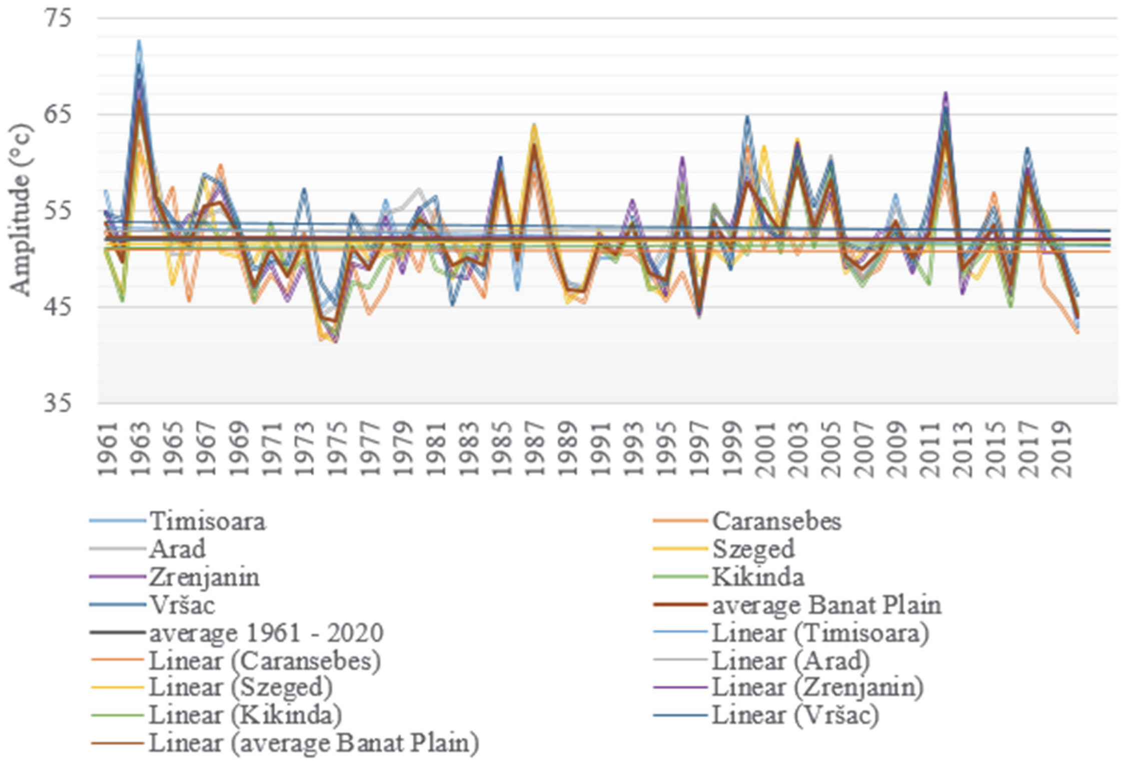

Fig. 16. Evolution of the annual absolute thermal amplitude at the analyzed meteorological stations.

Table 15. Evolution of the annual absolute thermal amplitude in the Banat Plain analyzed by Mann-Kendall trend tests

Station name	Trend equation	Min	Max	Mean	Std. deviation	Kendall's tau	p-value	Sen's slope
Timişoara	y=-0.0324x+53.219	42.9	72.6	52.23	4.851	-0.041	0.646	-0.014
Caransebeş	y=-0.0009x+50.806	41.6	62.2	50.78	4.744	0.004	0.964	0.001
Arad	y=0.0021x+52.868	43.8	65.2	52.933	4.719	0	1	0
Szeged	y=0.0102x+51.368	41.4	63.7	51.678	4.768	0.008	0.929	0.003
Zrenjanin	y=-0.0031x+52.307	41.3	68.4	52.211	5.340	-0.027	0.771	-0.017
Kikinda	y=0.0053x+51.140	42.1	65.8	51.304	4.875	-0.016	0.867	-0.007
Vršac	y=-0.0152x+53.826	44.6	70.0	53.359	5.157	-0.071	0.451	-0.026

Also, the values of the monthly absolute thermal amplitudes oscillate quite a lot from one year to another (*Fig. 17*), the amplitude of the oscillations is greater in the months of January-March and November-December, months for which there is generally a very slight downward trend in these values, a trend that cannot be confirmed by the result of the Mann-Kendall trend test, which does not confirm the existence of a trend for any month (*Table 16*).

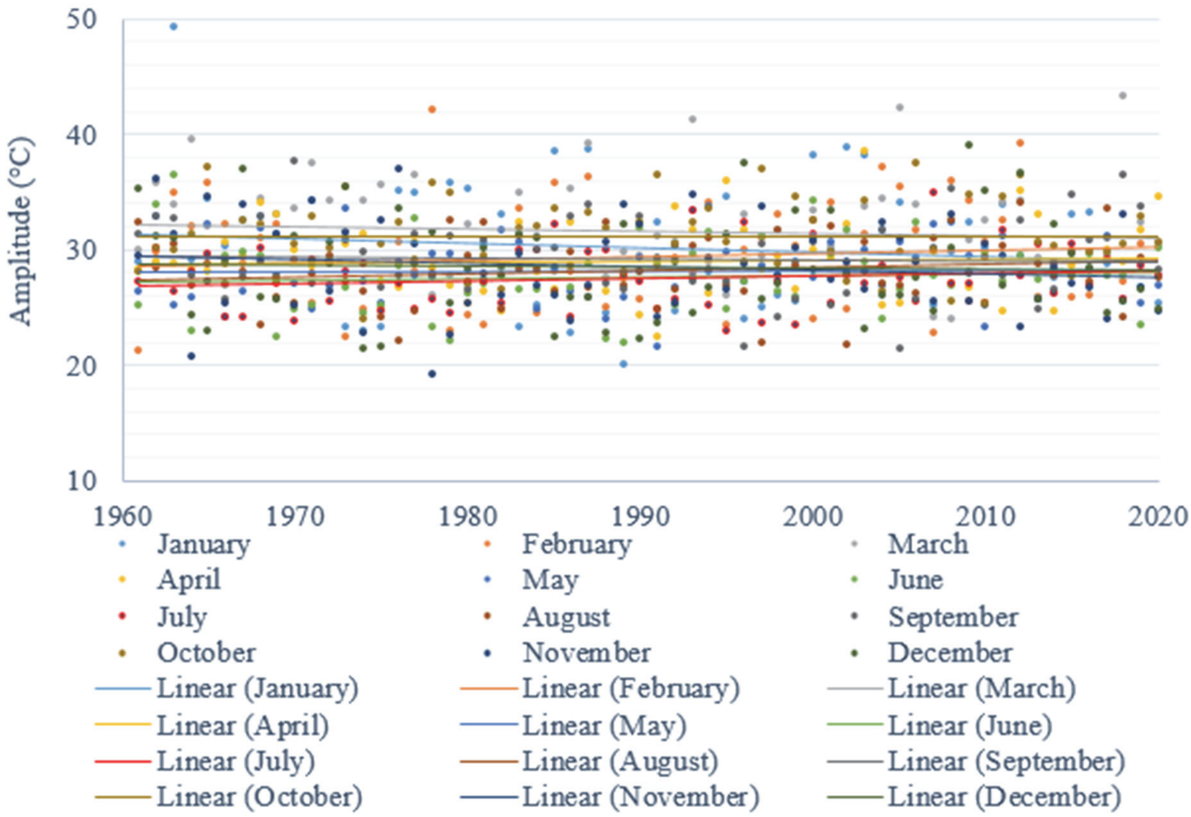

Fig. 17. Evolution of the monthly absolute thermal amplitudes in the Banat Plain.

Table 16. Evolution of the monthly absolute thermal amplitudes in the Banat Plain analyzed by Mann-Kendall trend tests

Month	**Trend equation**	**Min**	**Max**	**Mean**	**Std. deviation**	**Kendall's tau**	**p-value**	**Sen's slope**
January	y=-0.0410x+111.890	20.0	49.3	30.190	5.290	-0.053	0.549	-0.025
February	y=0.0277x-25.580	21.3	42.1	29.478	4.593	0.088	0.323	0.033
March	y=-0.0211x+73.570	23.9	43.3	31.603	4.329	-0.076	0.393	-0.028
April	y=0.0091x+10.971	22.4	38.5	29.023	3.202	-0.016	0.853	-0.004
May	y=0.0038x+20.519	21.6	33.7	28.135	2.664	0.064	0.471	0.016
June	y=0.0155x-3.1504	21.9	36.4	27.667	3.112	0.110	0.216	0.029
July	y=0.0219x-16.134	22.9	34.9	27.503	2.633	0.080	0.368	0.018
August	y=0.0280x-27.579	21.7	34.0	28.132	2.920	0.107	0.23	0.027
September	y=-0.0098x+48.770	21.4	37.7	29.213	3.344	-0.044	0.619	-0.012
October	y=0.0015x+28.050	24.0	37.5	31.108	3.144	0.014	0.878	0.004
November	y=-0.0307x+89.635	19.2	37.0	28.548	3.883	-0.096	0.281	-0.034
December	y=-0.0092x+46.869	21.4	39.0	28.507	4.287	-0.042	0.637	-0.015

4. Discussion and conclusion

The comparative analysis of all the parameters used is a good opportunity to find out the trends of the climatic evolution in the Banat Plain in the last six decades.

Tropical days (Td) are on average 32/year in the Banat Plain, the highest value is on average, 36.6 in Timişoara, the lowest is 24.5 in Caransebeș. The number of Td/year decreases in the 1970s compared to the 1960s, then increases steadily until nowadays, the increasing trend being confirmed even by the Mann-Kendall test, for all weather stations. The fewest Td occurred in the 1970s, the most in the 2010s. Of the monthly distribution we see significant increases in August, followed by July and June, increases confirmed also by the Mann-Kendall test.

Winter days (Wd) are on average 19.7/year in the Banat Plain, the highest value is on average, 22.4 in Szeged, the lowest is 16.6 in Vršac. The number of Wd/year decreases in the 1970s compared to the 1960s, then increases in the 1980s and decreases again until today, in the last decade the number of Wd is lower than in the 1970s. The fewest Wd occurred in the 2010s, the most in the 1960s. The Mann-Kendall test confirms the existence of a negative trend for this parameter at the level of the Banat Plain and most of the stations, except for Timişoara and Arad. However, the Mann-Kendall test does not confirm the existence of a trend in the monthly values of this parameter.

If we consider Td and Wd as potential climatic risk phenomena with a lower impact on the population, we can say that, from this point of view, the lowest risk in the Banat Plain was in the 1970s followed by a constant increase of this risk until nowadays, when the sum Td+Wd has the highest values. The increase observed for this parameter (Td+Wd) with a decreasing number of Wd, as well as a constant increase of the Td-Wd difference in the latest decades, which indicates a constant increase of the risk of high temperatures. The level of this increase exceeds the level of the decrease of the risk of low temperatures. The Mann-Kendall test confirms the existence of a positive trend for the two parameters, Td+Wd and Td-Wd.

Tropical nights (Tn) are on average 4.4/year in the Banat Plain, the highest value is on average, 10.9 in Vršac, the lowest is 2/year in Szeged. The number of Tn/year decreases in the 1970s compared to the 1960s, then steadily increases until nowadays, the increasing trend is confirmed also by the Mann-Kendall test for all weather stations. Identical to Td, the fewest Tn occurred in the 1970s, the most in the 2010s. From the monthly distribution we observe significant increases in August, followed by those in July and June. These increases are confirmed also by the Mann-Kendall test.

Frosty nights (Fn) are on average 9/year in the Banat Plain, the highest value is on average, 10.5 in Arad, the lowest is 8.3 in Zrenjanin and Caransebeș. The number of Fn/year decreases in the 1970s compared to the 1960s, then increases in the 1980s, decreases in the 1990s, increases in the 2000s, and decreases again until today. The fewest Fn occured in the 2010s, the most in the 1960s. The Mann-Kendall test confirms the existence of a negative trend for this parameter both at the Banat Plain level and for all meteorological stations, but does not confirm the existence of a trend in the monthly values of this parameter, only for the month of November, when the slope (Sen's slope) is 0.

Considering Tn and Fn as potential climatic risk phenomena with a medium impact on the population, we can again say that, from this point of view, the lowest risk at the Banat Plain level was in the 1970s, when the sum of Tn+Fn recorded minimum values, followed by an oscillating increase of this risk until nowadays. These oscillations are determined by the oscillation of the number of Fn, the slight increase of this parameter is also determined by the evolution of the number of Fn. The most risk remains in the 7th decade of the 20th century, with values of this parameter that have not been reached since then. Regarding the Tn-Fn difference, this also generally oscillates in line with the Fn number oscillations, the latter is much higher than the Tn in the 1960s, this difference is diminishing over time and finally, in the last decade, the Tn number exceeds the Fn number. The Mann-Kendall test confirms the existence of a positive trend in the difference between Td and Wd, but does not confirm the existence of a trend in the sum of Td+Wd.

Annual absolute maximum temperatures range from values below 35 °C, common in the 1960s and 1970s, to values above 40 °C, recorded in 2007 and 2017. A slight increase can be observed at all weather stations, which is confirmed by the Mann-Kendall test for all stations except Caransebeș. The same test also confirms the positive evolution of monthly absolute maximum temperatures at the Banat Plain level, but only for February, June, July, August, and December.

The absolute annual minimum temperatures are generally between -10 °C and -25 °C at all stations in the Banat Plain, with lows below -25 °C only in 2003, 2012, 1987, and 1963. In 1963 the temperature dropped to -35.3 °C. A slight increase can be observed at all meteorological stations, but this is not confirmed by the Mann-Kendall test at any station. However, the same test confirms the positive evolution of monthly absolute minimum temperatures at the Banat Plain level for July, August, September, and December.

Given that absolute maximum and minimum temperatures should be considered as climate hazards with a rather high impact on human society, we consider that an indicator in this respect could be the difference between them, namely the absolute annual amplitude. This shows the highest values of the last 6 decades in the 1960s and the lowest in the 1970s, continued by a slight increase in the 1980s, a decrease in the 1990s, and again an increase in the last 20 years, but not reaching the level of the 1960s. For this parameter we cannot speak of the existence of a trend, neither for annual nor for monthly amplitudes.

As a final conclusion, we can say that due to the general climatic warming that is also felt in the Banat Plain, the risk of high temperatures increases, while the risk of low temperatures does not decrease to the same extent. As for very high temperatures, although the risk of their occurrence is increasing, it is somewhat offset by the decrease in the risk of very low temperatures. The most affected decade of the last 6 decades is the 7th decade of the last century, and the least affected is the 8th decade. However, looking at the trends of these parameters over time, we can conclude that in the near future things may change, and we will no longer be able to say that in terms of temperature-related hazards, the situation is better than in the 1960s.

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