CLIMATOLOGICAL CHARACTERISTICS OF WINTER IN BUCIN MOUNTAIN TOP (GURGHIU MOUNTAINS, EASTERN CARPATHIANS)

O. RUSZ [1]

ABSTRACT. -Climatological characteristics of winter in Bucin Mountaintop (Gurghiu Mountains, Eastern Carpathians). In order to study the features of winter in Bucin Mountaintop, data collected from Bucin meteorological station (1270 m) were used. The Bucin mountaintop is situated in the central part of Gurghiu Mountains and it is a popular touristic destination. Several climatological parameters of the the cold months (November, December, January, February, March, April) in the period 1978-2010 were studied: mean temperatures, snow depth, snow cover, number of days with solid precipitation, etc. The mean temperature of these months is between -5.8°C (January) and 3.1°C (April). The absolute minimum temperature (-26.1°C) since the Bucin weather station functions (from 1978) was registered in February 1985 (in case of nearly mountain depressions this value approached -40°C). Generally, durable snow cover is present from November to April and on average 150 days/year are covered by snow. The highest mean snow depth is registered in March (76 cm). According to the Köppen asymmetric index the number of years that have lower snow depth that average is higher in case of all months. Mean number of frosty days (annual count of days when T_{min} < 0°C) is 161, of extremely cold days (annual count of days when T_{min}< -10°C) is 44 and of winter days (annual count of days when T_{max} < 0°C) is 75. Correlation tests (Pearson) show statistically significant values in case of snow depth and mean temperature for almost all months, but in January and February, there are no statistically significant correlations between snow depth and precipitation amounts respectively number of days with solid precipitation. Generally, there are no statistically significant trends (Mann-Kendall tests) regarding these climatological parameters typical for winter.

Keyword: winter, climate, Bucin Mountaintop

1. INTRODUCTION

Gurghiu Mountains belong to a volcanic chain of the Eastern Carpathians. They are placed between Mureş and Târnava Mare rivers. Road DN13 crosses these mountains, connects the Praid-Sovata zone and Giurgeu Depression. The highest peak does not exceed 2000 m. The mountains are covered by coniferous and mixed forests with a rich wildlife. Bucin mountaintop is situated in the central part of Gurghiu Mountains and is a popular touristic destination, mainly in winter.

[1] Târgu Mureş Meteorological Station, Libertăţii Street, No. 120, Târgu Mureş, Romania, e-mail: ruszotti@freemail.hu

The Bucin meteorological station is situated at western part of a mountainside, approximately at a distance of 800 m from road DN13.

2. DATA AND METHOD

Data collected from the Bucin meteorological station (1270 m elevation) in period 1978-2010 (November, December, January, February, March, April) were used. The following meteorological parameters were studied: mean monthly temperature, monthly maximum and minimum temperature, precipitation amount, number of days with solid precipitation, number of days with snow-cover, snow deepth (Fig. 1), mean number of frosty days (annual count of days when $T_{min} < 0°C$), of extremely cold days (annual count of days when $T_{min} < -10°C$), and of winter days (annual count of days when $T_{max} < 0°C$), number of days with rime (Fig. 2). Using XLSTAT software (http://www.xlstat.com), box-plots of mean temperature and precipitation amount are presented. The first and the last appareance of durable snow are shown using relative histograms (percents). Those climatic elements that are inferior limited (eg. snow deepth) have a distorted distribution, which asymmetry are expressed by Köppen asymmetric index: A=1-(2na/n) (where n= total number of set and the number of members with less value than the total number of set). The characteristic of this distribution is that the value with the greatest probability is not equal to the mean value (Péczely, 1998).

Fig.1. One of the rulers of snow measure almost 120 cm of snow depth

Time distribution figures of snow depth were realized using spline with barriers interpolation method and ArcGis 10.1 software (http://www.esri.com). In order to assign which climatological elements influence mainly the snow depth, the Pearson correlation test was applied. Linear trends of these climatic parameters

proper to winter were determined using Mann-Kendall tests (Mann, 1945; Kendall, 1975), Sen's slope estimate (Sen, 1968) and Makesens software (Salmi et al., 2002).

Fig.2. Rime on the enclosure of Bucin meteorological station

3. RESULTS AND DISCUSSION

Box plots of mean temperatures and precipitation amounts of cold months are presented in Fig. 3 and 4.

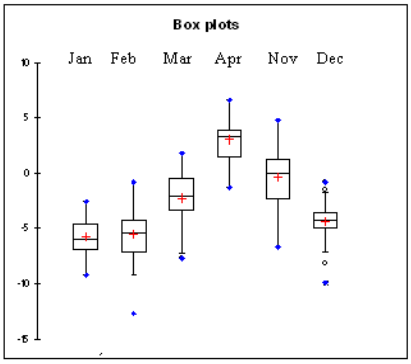

Fig.3. Box plots of mean temperatures

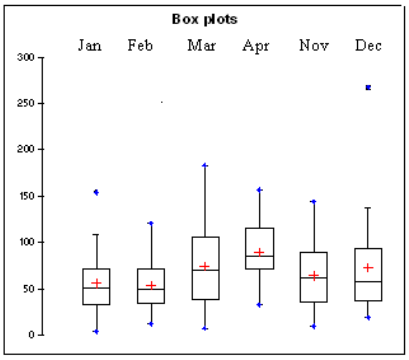

Fig.4. Box plots of precipitation amounts

The mean temperature only in April exceeds 0°C. January is the coldest month, with mean temperature equal to -5.8°C. November and March are the most

variable months regarding mean temperature, and March regarding precipitation amounts. There is a well-marked „outlier" in December, due to high precipitation amount in December 1995 (267.7 mm/month, the 106.7 mm registered in 27.12.1995 contributed to this high value). The mean annual number of days with solid precipitation is 86. In spite of the fact that mean monthly (and annual) temperature is relatively low, the minimum temperature is not below -26.1°C since 1978. The minimum temperature in nearly mountain depressions approached -40°C for the same period (1978-2010): -34.8°C at Joseni and -38.4°C at Miercurea Ciuc meteorological stations. It should be noted that the absolute values of minimum temperature is also negative for May, June, September and October. Table 1 presents the absolute maximum and minimum temperature of the cold months from the studied period:

Table 1. Absolute minimum and maximum temperature of cold months (°C)

	January	February	March	April	November	December
Maximum temperature	12.6	14.3	18.0	21.0	20.6	12.3
Minimum temperature	-24.5	-26.1	-26.0	-12.6	-25.1	-22.4

Durable snow cover is present from November to April and on an average of 150 days/year are covered by snow (number of days with rate of snow cover higher or equal to 6/10). In higher areas of our country, snow layer can appear in September, and remains until June (Bogdan, 1978). Due to the fact that Bucin has lower altitude, winter persists for a shorter time.

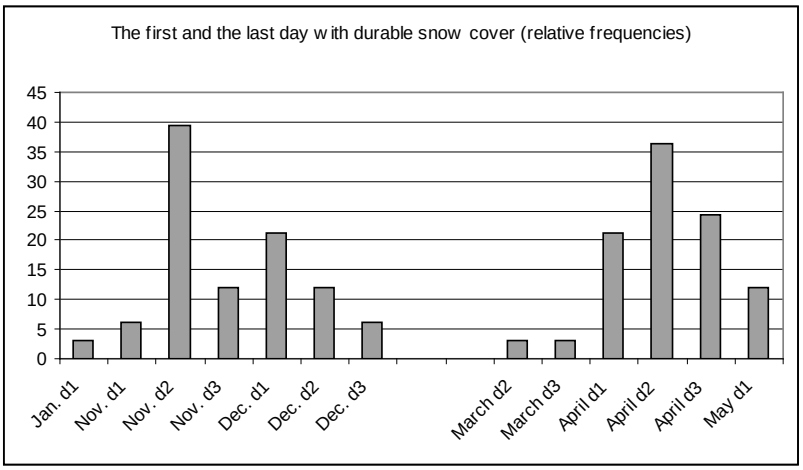

Fig.5. Relative frequencies (percentage) of the first and the last days with durable snow cover. D1, d2, d3 mark the first, the second and the third decade of the mentioned months

The relative frequencies of the first and the last days with durable snow cover are presented in figure 5.

Monthly mean snow depth and Köppen asymmetric index values are shown in Table 2.

Table 2. Monthly mean snow depth and Köppen asymmetric index for each month

	January	February	March	April	November	December
Mean Snow depth	54	74	76	33	8	25
Köppen asymmetric index	-0.03	-0.15	-0.15	-0.09	-0.21	-0.09

The highest monthly mean snow depth is registered in February and March, as revealed time distribution figure of snow depth too (Fig. 6).

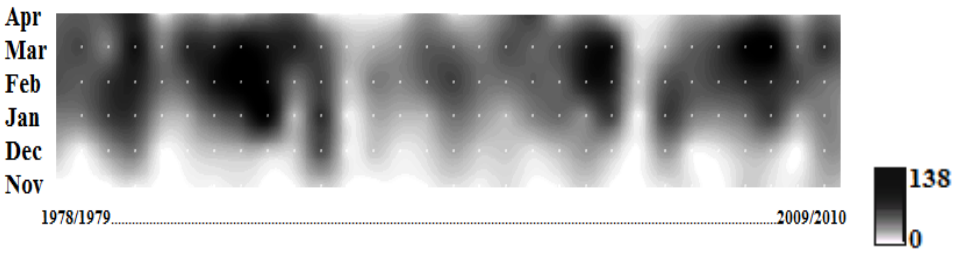

Fig. 6. Time-distribution figure of snow depth. The colours represent different values of snow depth (monthly means) between 0-138 cm. Spline with barriers interpolation method was applied using ArcGis 10.1 software

In all cases Köppen asymmetric index have negative values, therefore the number of years that have lower snow depth on the average is higher in case of all months.

The mean number of the frosty days (annual count of days when $T_{min} < 0°C$) is 161, extremely cold days (annual count of days when $T_{min} < -10°C$) is 44 and winter days (annual count of days when $T_{max} < 0°C$) is 75. A typical winter phenomenon is the rime, which is formed on different objects in the presence of fog. The mean number of days/year with rime in Bucin is 13. Drifting snow is formed when the speed of wind is high, the annual mean number of days with drifting snow is 19.

Correlation test results between snow depth and other climatological elements for all studied months. This is presented in Table 3.

Except December, there are statistically significant negative correlations between the mean monthly snow depths and temperature (the mean monthly

temperature, mean of maximum and minimum temperature of the months). The amount of precipitation affects only the mean snow depth in November (there is statistically significant and positive correlation between these climatological parameters). In January and February, there are no statistically significant correlations between the snow depth and the number of days with solid precipitation. It seems that mainly the temperature is responsible for the measure of snow thickness.

Table 3. Correlation coefficients between snow depth and other climatic elements (MMT= mean monthly temperature, MT_x= average of maximum temperatures for each month, MT_n= average of minimum temperatures for each month, RR= precipitation amount, SP= number of days with solid precipitation). Bold values are statistic significants (at level 0.05)

	MMT Jan	MT_x Jan	MT_n Jan	RR Jan	SP Jan
Snow depth Jan	**-0.509**	**-0.486**	**-0.505**	0.271	0.102
	MMT Feb	MeanMax Feb	MeanMin Feb	RR Feb	SP Feb
Snow depth Feb	**-0.406**	**-0.413**	**-0.421**	0.073	0.005
	MMT Mar	MeanMax Mar	MeanMin Mar	RR Mar	SP Mar
Snow depth Mar	**-0.529**	**-0.524**	**-0.518**	0.324	**0.379**
	MMT Apr	MeanMax Apr	MeanMin Apr	RR Apr	SP Apr
Snow depth Apr	**-0.758**	**-0.739**	**-0.756**	0.289	**0.677**
	MMT Nov	MeanMax Nov	MeanMin Nov	RR Nov	SP Nov
Snow depth Nov	**-0.571**	**-0.601**	**-0.546**	**0.572**	**0.666**
	MMT Dec	MeanMax Dec	MeanMin Dec	RR Dec	SP Dec
Snow depth Dec	-0.338	**-0.372**	-0.297	0.265	**0.542**

The results of Mann-Kendall test (Sen's slope estimate) for monthly mean temperature, monthly mean snow depths and monthly precipitation amounts are shown in the Table 4. Statistically significant and positive trends (at significance level 0.05) are in case of mean temperature in April, precipitation amount in March and November and snow depth in November

Table 4. Trend analysis with Mann-Kendall test and Sen's slope estimate for monthly mean temperatures, monthly mean snow depths and monthly precipitation amounts. Bold values are statistic significants (at level 0.05)

	January	February	March	April	November	December
Mean temperature	0.045	0.043	-0.009	**0.080**	0.075	0.015
Precipitation amount	-0.298	0.500	**1.806**	0.164	**1.072**	-0.459
Snow depth	-0.250	-0.513	0.321	-0.606	**0.223**	-0.054

Regarding to the annual number of days with rime, number of days with drifting snow and number of frost days, one can observe negative, statistically

significant trends (at significance level 0.01), thus the number of days with these climatological elements indicate a decreasing trend. In case of the number of days with snow cover, number of days with solid precipitation, extremly cold days and winter days there are no statistically significant trends (Fig.7)

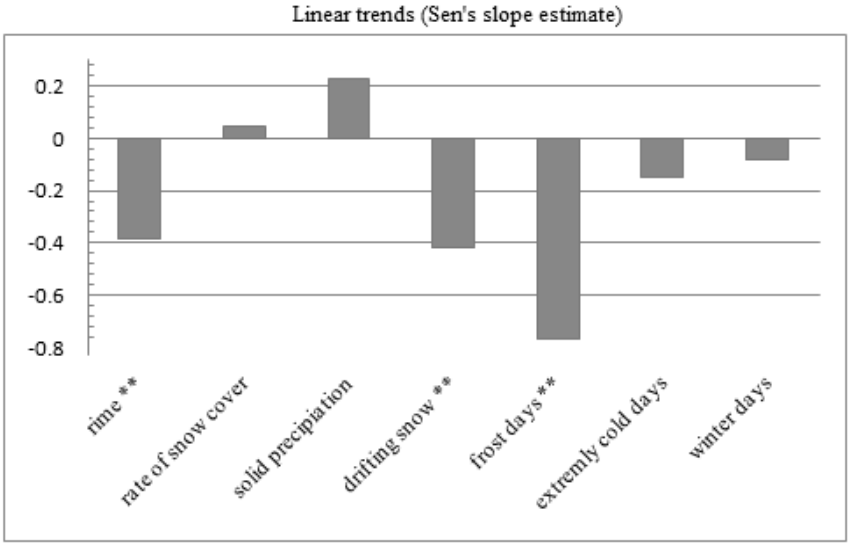

Fig.7. Slope of trends (Sen's slope estimate) of the following climatic elements: number of days with rime, number of days with snow cover, number of days with solid precipiation, number of days with drifting snow, number of frosty days, number of extremly cold days, number of winter days. The trend of climatic elements marked with * are statistically significant (at level 0.01)

4. CONCLUSIONS

Winter characteristics of Bucin Mountaintop (Gurghiu Mountains) were studied using meteorological data collected from Bucin station, in period 1978-2010. However, usually the meteorological winter is present from December 1st till the end of February, in Bucin Mountaintop generally winter begins in November and persists until April. The mean temperature of the cold months (November-April) is between -5.8°C (January) and 3.1°C (April). The absolute minimum temperature (-26.1°C) since the Bucin weather station functions (from 1978) was registered in February 1985. It's remarkable that in case of nearly mountain depressions, at Joseni and Miercurea Ciuc stations, this value approached -40°C in the same period. The highest mean snow depth is registered in February (74 cm) and March (76 cm). According to the Köppen asymmetric index, the number of years that have lower snow depth that average is higher in case of all months, therefore the numbers of years that have lower snow depth that average is higher in case of all months. Mean number of frosty days (annual count of days when T_{min} <

0°C) is 161, of extremely cold days (annual count of days when T_{min} < -10°C) is 44 and of winter days (annual count of days when T_{max} < 0°C) is 75. Correlation tests (Pearson) show statistically significant negative values in case of snow depth and mean temperature for almost all months, but in January and February, there are no statistically significant correlations between snow depth and precipitation amounts respectively the number of days with solid precipitation. Statistically significant and positive trends (at significance level 0.05) are in case of mean temperature in April, precipitation amount in March and November and snow depth in November, respectively negative, statistically significant trends (at significance level 0.01) in case of numbers of days with rime, number of days with drifting snow and number of frosty days. Winter climatological condition in Bucin Mountaintop persists from November to April, nevertheless the optimal period to practice winter sports it is between January-March.

REFERENCES

1. Bogdan, O. (1978). *Fenomene climatice de iarnă şi de vară.* Editura Ştiinţifică şi Enciclopedică, Bucureşti, 120 pag.
2. Kendall, M.G. (1975): *Rank correlation method*, 4th Ed., Charles Griffin, Londres
3. Mann, H.B. (1945*): Non-parametric test against trend.* Econometrica, 13, pp. 245-249.
4. Péczely, G, 1998. *Éghajlattan*. Nemzeti Tankönyvkiadó, Budapest, 336 pag.
5. Salmi, T., Määttä, A., Anttila, P.,Ruoho-Airola, T., Amnell T. (2002*): Makesens 1.0. Mann Kendall test and Sen's slope estimates for the trend of annual data.* Version 1.0. Freeware. Finnish Meteorological Institute, Helsinki.
6. Sen, P.K. (1968): *Estimate of the regression coefficient based on Kendall's tau.* Journal of American Statistical Association, 63, pp. 1379-1389.
7. *** *Meteorological tables (TM1) from Bucin station* from period 1978-2010.