THE EVALUATION OF PLUVIOMETRIC RISK IN PĂLTINIȘ TOURISTIC AREA

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Abstract. In terms of climate change, the adaptation to weather conditions in vulnerable areas is of great importance, as it is the case of mountainous areas. Among the geographical factors, the relief has a determinant role in the rainfall regime, establishing itself by altitude, slope orientation, and configuration of its forms. Altitude causes vertical change of all climatic elements. Rainfall increases as altitude increases, up to a certain height called pluviometric optimum beyond which it begins to decrease. For specific winter sports in the highlands and agritourism in the lowlands, a persistent and consistent snow cover generated by solid precipitation is almost mandatory. The snow and the snow cover ensure good conditions for skiing at altitudes > 1600 m, due to its natural potential and the superior capitalization of modern equipments ski tracks have. Considering the specific agro-pastoral and tourist activity in the area of Pălținiș, environmental quality improvement depends on encouraging environmentally friendly practices.

Keywords: risk, pluviometry, snow cover, natural potential, environmental quality.

Rezumat. Evaluarea riscului pluviometric în arealul turistic Pălținiș. În condițiile schimbărilor climatice, adaptarea la condițiile meteorologice în zonele vulnerabile este de mare importanță, cum este cazul zonelor montane. Printre factorii geografici, relieful are un rol determinant în regimul precipitațiilor, fiind direct dependent de altitudine, orientarea versanților și configurație. Altitudinea cauzează modificări pe verticală ale tuturor elementelor climatice. Precipitațiile cresc pe măsură ce crește altitudinea până la o anumită înălțime, numită optim pluviometric, dincolo de care începe să scadă. Pentru practicarea sporturilor specifice sezonului rece în regiunile înalte şi a agroturismului în regiunile joase existenţa unui strat de zăpadă persistent și consistent, generat de precipitațiile sub formă de ninsoare sunt condiții aproape obligatorii. Ninsoarea și stratul de zăpadă asigură condiții bune pentru practicarea schiului la altitudini > 1600 m, prin potenţialul natural bogat și printr-o valorificare a mijloacelor moderne de dotare a pârtiilor la valențe superioare. Având în vedere activitatea specific agro-pastorală și turistică a arealului stațiunii Pălținiș, componenta de îmbunătățire a calității mediului depinde de încurajarea practicilor ecologice.

Cuvinte cheie: risc, pluviometrie, strat de zăpadă, potențial natural, calitatea mediului înconjurător.

INTRODUCTION

The Climate Resort Pălținiș was founded in 1894 by SKV (Transylvanian Carpathian Society - Siebenbürgischer Karpathen-Verein) and it is the oldest resort in the country, located at the highest altitude of 1442 m. Pălținiș resort is among the oldest and most representative tourist regions of Romania (Fig. 1).

Figure 1. Old postal card representing Pălținiș Resort (Dragoteanu M., personal archive).

For tourism activities, solid precipitation has favourable effect. For practicing specific winter sports in the highlands and agritourism in the lowlands, a persistent and consistent snow, generated by precipitation in the form of snow, is very important. Snow accumulates and forms the snow cover, important for its thickness and persistence in terms of socio-economic activities in the area of study.

MATERIAL AND METHODS

This paper is based on climate data analysis, more specific on average, maximum and minimum precipitation quantities, including solid precipitation, and depth of the snow cover. The data were taken from the meteorological station Păltiniș and analyzed compared to the elevation, since the relief influences by the height and slope exposure the presence of snow on the ground (CROITORU, 2003).

The range of climatic parameter analysis is 1986-2015, given that an emphasis on the variability of the precipitation should be on a longer period of time and using homogeneous data.

From the climatic perspective, an area is considered to be optimal for winter sports if there are not registered extremely low negative temperatures or blizzards; there are also added the average lifetime of the snow cover at least 120 days / year and the average thickness of the snow cover at least 15-20 cm per ten-day intervals (***. National Institute for Research - Development in Tourism, 2003).

The average annual number of days with snow cover is 208 days at Păltiniș and more than 280 days on the highest peaks. At Păltiniș, where the risk of melting in winter is lower, the average thickness of snow increases gradually, from early autumn to late spring, due to the accumulation of fresh snow fallen over the existing layer (Table 1).

Table 1. Climatic suitability for practicing winter sports at Păltiniș between November and March.

Favorable climate indicators for winter sports	Păltiniș (1450 m)
Average of minimum air temperatures	2,7°C annual or -4,9°C (November-March)
Average of maximum air temperatures	9,5°C annual or 2,5°C (November-March)
The duration of time interval with snow cover	208 days
The number of days with snow cover with thickness greater than 20 cm	100 days
The average date of the first snow	18 October
The average date of the last snow	10 May
The number of days with frost (minimum temperature below 0°C)	142 days

With regard to the spatial distribution of rainfall, there is an increasing amount in parallel with the increase in height until reaching the optimum precipitation (as the amount of precipitation decreases slowly), the situation demonstrated in the case of Păltiniș, where the annual average quantity is 915.4 mm, although the cloudiness is not so high.

Inverse correlation between cloudiness and rainfall occurs only at the annual analysis and is due to the persistence of stratiform clouds developed during the cold semester above the depression, which generate reduced precipitation quantities. On the contrary, in the warm semester, the thermal and frontal convection increases and the cumuliform clouds, which give heavy rain showers, and cloudiness is bigger at Păltiniș.

Regarding the seasonal distribution, from the total annual rainfall 12.9% (118.2 mm) fall in winter, 27.9% (255.3 mm) fall in spring, 39.4% (360.6mm) fall in summer and 19.8% (181.3) fall in autumn. The annual regime is characterized by the increase of the rainfall quantities from February to June and their decrease from July to February, with one exception (in December 42.7 mm). The minimal precipitation amount registered in January (34.2 mm) is due to the very low cloud systems related to the fronts coming from the Mediterranean cyclones; the southern and western slopes of the Carpathians receive most of the precipitation amount. The maximum in June (135.3 mm) is due to the increased Atlantic cyclone activity, when moist ocean air enters the northern part of the ridge and to the eastern Azores High; at the same time, thermal convection becomes more intense, increasing precipitation amount by 17 mm.

The greatest amount of precipitation occurred in years of intense cyclonic activity and low amounts of rainfall occurred in years when continental anticyclone regime and penetration of air from North Africa predominated. The precipitation amounts on short intervals do not always have a torrential nature, but in some cases, in favorable synoptic situations (the consequence of strong convective processes) they totalize in 24 hours a higher amount than the average of the respective month (April 1933, 110.4 mm compared to the average of the month from the period 1986-2015 of 81.1 mm). The maximum amount of rainfall in 24 hours in the period 1986-2015 was 76.8 mm and it was recorded on May 8, 1987, and the absolute maximum amount of rainfall in 24 hours was recorded in April 1933, 110.4 mm (Table 2).

Table 2. The monthly average and maximum amount of rainfall (mm) in the interval 1986 to 2015 at Păltiniș.

Rainfall	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Average of rainfall quantity	34.2	41.3	56.4	81.1	117.8	135.3	118.8	106.5	85.4	57.1	38.8	42.7	915.4
Monthly maximum in 24 h	30.1	36.7	39.1	59.5	76.8	68.6	67.4	57.4	62.4	56.0	37.8	26.6	76.8
Absolute maximum in 24 h	33.8	36.7	40.1	110.4	76.8	88.3	68.1	78.4	62.4	56.0	37.38	32.2	110.4

Source: processed data from Păltiniș weather station

Given the configuration of the relief - slight slopes (under 6° inclination), moderate slopes (6° to15°) and few areas with very steep slopes (15° to 30°), respectively the high density of the coniferous forests, in the area Păltiniș, there is no strong phenomenon of soil erosion even if rainfall reaches great amounts, such as 76.8 mm in 24 hours, produced on April 8.

The snow and the snow cover ensure good conditions for skiing at altitudes > 1600 m, due to its natural potential and the superior capitalization of modern equipments ski tracks have. In the Carpathians, the ski area has just a small share of the total area of about 70,000 km^2 (ERDELI & GHEORGHILAŞ, 2006).

Snow represents one of the characteristics of the high mountain regions, which is characterized by the amount, intensity, frequency and duration, contributing effectively to the formation of the snow cover. Calendar data which delimits the possible duration of snow fit, as a rule, between the average data of the first and last days of snow. The average data of the appearance and disappearance of the snowfall are dependent on the thermal values recorded at the end of the autumn, early winter and early spring when, in general, minimum average daily temperatures are 2-3 °C, but they are directly dependent on elevation. Thus, the first snowfalls are early in the highlands, > 2000 m (Cindrel Peak on September 8) and increasingly delayed as the altitude decreases (Păltiniș, October 8) as a result of the cooling processes produced from the lowest to the highest altitude. Also, the last snow disappears early at lower altitudes, due to the fact that heating processes occur from the lowest to the highest altitude. At Păltiniș, the last snow occurs, on average, on the May 10.

The extreme dates of the first snowfall, compared to the average dates of autumn, are possible almost one month and a few days earlier, at 1453 m altitude (Păltiniș, September 14) and almost two months earlier at > 2000 m altitude (Cindrel Peak 2224 m). Also, compared to the average dates of the last snow of the spring, the latter snow are possible about a half month later, at about 1453 m (Păltiniș, May 25) and approximately one month later, at more than 2000 m (2224 m Cindrel Peak).

Due to the wide variability of climate, snow is possible in any month of the year to over 2000 m altitude and range from September to May at Păltiniș, contributing, to the possibility of practicing winter sports (skiing, snowboarding and snowmobile). An average interval between possible snow data is within the average snowfall production and it shows a proportional increase with altitude, according to a vertical gradient of 7-8 days / 100 m.

An average duration of this interval varies from about 208 days at altitudes of 1453 m (208 days at Păltiniș) and 240 days on the highest ridges. The maximum possible range with snow between the earliest and the latest dates of the occurrence of the first snow of autumn and the late snow of spring is 300 days at over 2000 m altitude, and increasingly lower as the altitude decreases (253 days Păltiniș). The smallest duration possible, ranges from 145 days to 225 days at Păltiniș and Cindrel Peak.

The minimum, average and maximum monthly number of days with snow, unlike the possible duration interval with snow, includes exclusively the number of days with solid precipitation that generate snow cover. Being conditioned by the lower temperatures of the air, but also by the atmospheric circulation, the distribution across Massif Cindrel is largely determined also by altitude and slope orientation (BLANCHET, 2009).

On average, snowfalls occur between 68-69 days/year at Păltiniș and 87 days/year on Peak Cindrel. Within these limits, it is placed the Meteorological Station Păltiniș, where the multiannual averages have values of about 69 days/year. The maximum number of days with snow from a year varies between 97 and 99 days at Păltiniș and 137 days on Cindrel Peak (Table 3).

Table 3. Average, minimum and maximum number of days with snow at Păltiniș between 1986 and 2015.

Dates Păltiniș/ month	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Total**
Average	10.9	10.8	11.1	7.2	1.3				0.3	3.2	6.9	10.4	68.5
Minimum (2008)	6	7	5	3						1	3	11	36
Maximum (1987-1988 and 2004-2005)	23; 26	9; 18	18; 15	15; 6	4					3	12	18; 10	99; 90

Source: processed data from Păltiniș weather station

During the year, the distribution of the values shows a gradual increase of the monthly average number of days with snow, from August (Cindrel Peak) and September at Paltinis, reaching a maximum in winter and spring months (December, January, February and March (10.4; 10.9; 10.8; 11.1 days at Păltiniş), values that diminishes with increasing proportion of days with positive temperatures.

RESULTS AND DISCUSSIONS

The non-periodic variability of the number of days with snow in the Carpathian sector of Cindrel, during the period 1986-2015 highlights several aspects:

- at the meteorological station Păltiniș, positive deviations from the annual average have a higher share at the expense of negative in the first interval, and negative in the second;
- the higher deviations (positive) from the multiannual average in the analyzed which were recorded at Păltiniş were +30.5 and +29.5 days in 1987-1988 and 2013 and the lowest deviation (negative) from the annual average which was also recorded at Paltinis were -45.5 and -48.5 days in the winters 2009 and 2012;
- in the Carpathian sector of Massive Cindrel, the number of days with snow is in decline, registering a higher concentration of negative deviations from the annual average in the last part of the analyzed period (after 2005);

- in the last decade in particular, there is a sustained trend of reducing the number of days with snow on the background of global climate warming compared with the first period analyzed (1986-2005), when there is an alternation of positive and negative deviations.

The snow is a meteorological element particularly vulnerable to the effects of global warming, through the dependence on temperature, precipitation and wind (HAIDU, 2002). It is an important resource for tourism, water supply and energy production, but can cause some major natural hazards (avalanches, blizzards). Regarding the winter sports practice, snow is a source of economic development for the people around the mountain resorts and tourism resorts depending on the existence and persistence of snow thickness, optimal for sports specific to the cold season (ski, snowboard).

It was found that investments in the development of mountain tourism resorts where winter sports are profitable are made only if the number of days with snow per year is more than 100. Changes arising from global warming in the existence and persistence of snow may have direct implications on natural mountain habitat (rivers and ecosystems) and indirect in terms of economic activities.

The average data of the occurrence and persistence of snow are dependent on the average data for the first and last snowfall, which depends on the thermal regime, air circulation and wind regime.

The first snow, as average date, is in autumn, about four days later than the first snow at an altitude of 1453 m (Păltiniș), being increasingly closer to the date when the first snow falls as the altitude increases. The last snow disappears in spring, six days later than the last snow at about 1453 m altitude (at Păltiniș on the May 16) or 10-15 days later, as the altitude increases.

The extreme dates of the appearance and disappearance of snow are important both in terms of range of risk for snow, but also in terms of economic activities, by the damage it can make to society and above all to the tourism operators in the resort area. In the autumn, the emergence of snow associated with severe frost or snow storms can adversely affect transport in the region, given the transit taking place on DN 7 (it should be noted here the hearty snow from the autumn of 1995 between October 31 and November 5, when the access to the resort was blocked on DJ 106A for six days). In spring, sudden melting of snow may cause flooding (as the flooding in 1977) and reduce favorable period for practicing specific winter sports. Instead, the presence of the snow cover during late spring (as was the case in 1997), on the one hand, can promote tourism activities specific to the cold season, and on the other hand can increase the contingency of avalanches.

The earliest snowfall is possible at altitudes >2000 m, from the second decade of August (August 15 on Cindrel Peak), with delays of about a month at smaller altitudes (September 15 at Păltiniș). The latest snow (autumn) is possible about two months later than the average date. It produced at Păltiniș station during the second decade of November (November 17, 2000). The earliest snow (spring) first melts at altitudes of about 1453 m in the first decade of April (April 5 at Păltiniș) and gradually later as the altitude increases. The latest snow (spring) may resists even in summer, until the first decade of June (June 1, 1991 and June 5, 1997 at Păltiniș).

An average of the period with snow cover (between the average date of the first and the last day with snow) varies between 210 days at altitudes of 1453 m (Păltiniș) and 300 days at altitudes > 2000 m (Cindrel Peak). The maximum possible duration of this period (from extreme data, the earliest and that the latest snow) ranges from 259 days at Păltiniș to 300 days on Cindrel Peak. Minimum possible interval with snow is of 154 days at Păltiniș, but the value increases up to 228 days, at Cindrel Peak.

The minimum, average and maximum monthly days with snow is lower than the likely duration of snow cover, because hot air invasions occur in winter, when fallen snow melts. The average annual number of days with snow cover is about 222 days at high altitude and about 140 days at the resort. The maximum number of days per year with snow on the Cindrel Peak exceeds 262 days, and at Păltiniş, it oscillates around 188 days (year 1988). During the year, most days with ground covered with snow are in January (30 to 31 days / month), provided that at altitudes > 2000 m, the same maximum values (31 days / month) persists into early spring, in March. The number of days with snow cover reduces with the increasing proportion of days with positive temperatures. At more than 2000 m, the snow remains even during the warm season, when recording the smallest number of days with snow-covered ground (between 0.3 and 0.8 days / month of August and July). At Păltiniș, they occur in September (0.1-0.2 days / month).

Non-periodic variability of the number of days with snow cover determines the Massif Cindrel tourist vocation for practicing winter sports. If at altitudes >1500 m (Păltiniş weather station), positive deviations of the number of days with snow from the annual average have a lower frequency at the expense of negative deviations, at altitudes <1000 m, the prevailing negative deviations at the expense of positive throughout the period analyzed (1986-2015), indicate greater frequency of winters with less snow due to global warming (NICULESCU, 1996).

The greatest deviation (positive) of the number of days with snow-covered ground during the period 1986 to 2015 was recorded at Păltiniș Resort in 1988 (of + 48zile) and the smallest deviations (negative) from the multiannual average at Păltiniș Station, in winters 2010 and 2014 (to -61 or -58 days). In terms of number of days with snow cover, there was a sustained reduction at Păltiniș after 2005. This shows that, with global warming, the duration of possible time with snow drops and thickness decreases (Fig. 2).

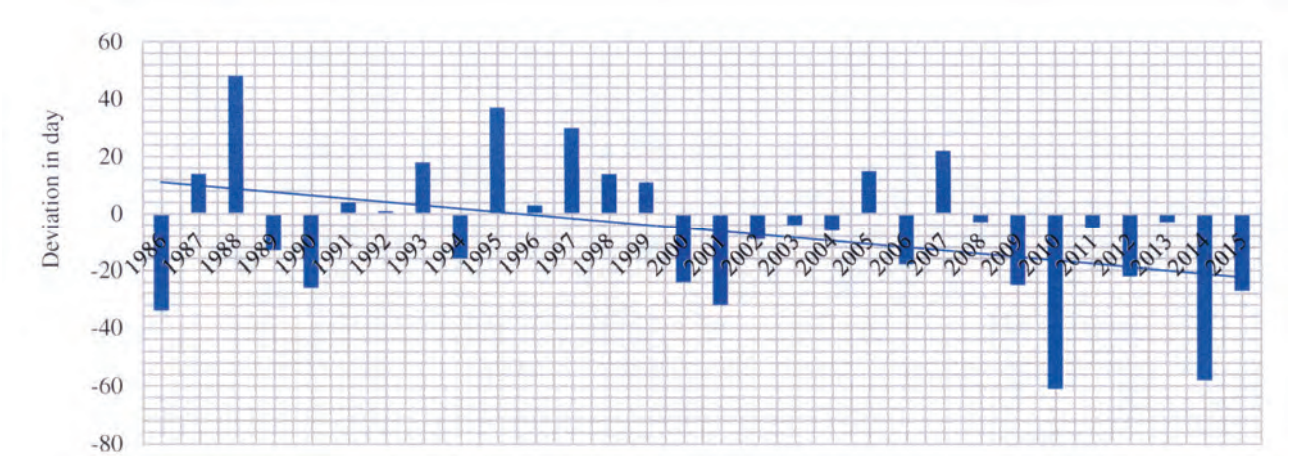

Figure 2. Variability of the number of days with snow cover at Păltiniș, between 1986 and 2015.

Average thickness and maximum decadal and monthly snow cover is an important source for tourism activity undertaken by people around mountain resorts where winter sports are practiced. Economic profitability of the tourism resorts is consistent with the presence of snow that has the appropriate thickness (at least 15-20 cm thick) for skiing. Eckel (1938, cited by LATERNSER & SCHNEEBELI, 2003) highlighted the thresholds of the thickness of the snow layer as a prerequisite for the skiing resorts in Switzerland, showing the thickness of 30 cm is considered sufficient, 50 cm is the optimum thickness and the 70 cm is great for skiing (Table 4).

Table 4. Average, minimum and maximum thickness of the decadal and monthly snow cover at the meteorological station Păltiniș (1986-2015).

Păltiniș/month	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Average**
Average decade I	27	37	39	21	1					1	4	12	17,8
Average decade II	28	45	44	16	1					1	5	19	20
Average decade III	32	42	35	5	1				1	1	10	21	18,4
Monthly average	27	38	35	12	1					1	6	17	17,3
Maximum 1997 II 2006 II	7 49	21 68	9 107	102 6							10 6	26 2	21,9 29,8
Minimum 1986 I II	4 10	5 9	8 2								2 1	0 5	2,4 3,4
Monthly maximum 2005	31	79	81	4						2	14	29	30
Monthly minimum 1986	5	8	4							3	1	8	3,6

Source: Processed data after National Meteorological Administration archive

The variation in time of the thickness of the snow cover is determined both by the values of solar radiation, which becomes minimum on the winter solstice and the geographical position of the massif Cindrel (exposure to sunlight or exposure to north), determined by the characteristics of the general circulation of the atmosphere.

At about 1453 m altitude (Păltiniș), the monthly average thickness of the snow cover gradually increases from early autumn (September or October) until second part of spring (April-May). At more than 2000 m (Peak Cindrel), the range for the production of snow is from September to May, but it may also range from August to May. The highest decadal average thickness of snow is reported in the second decade of February and March (45-44 cm). In terms of winter sports (skiing, snowboarding), monthly average thickness of the snow cover is considered sufficient at Păltiniș Resort between January and March.

The maximum thickness of the snow cover, in contrast to average values, is generated by exceptional circumstances, in the first place determined by the characteristics of the general circulation of the atmosphere. Heavy snowfalls may fall in certain winters as it was the case in 2004, 2005 and 2006, and previously analyzed period in the winter 1953-1954, when in the valleys, the snow reached 18 m thickness (TOPOR, 1957; BOGDAN & DRAGOTĂ, 2000).

In general, the highest decadal maximum thickness of the Carpathian Massive Cindrel ranged between 102 and 107 cm at Păltiniș (in the second decade of April 1997 and March 2006) and over 2,000 cm on the highest mountain peaks.

Due to the fact that the measurements were made in sheltered places, the maximum thicknesses are somehow not influenced by blizzards (SOROCOVSCHI, 2003).

Compared to other ski resorts (, the Alps, the Caucasus and the Balkans), the Massif Cindrel and Păltiniş cannot be considered very favorable for practicing winter sports (except Onceşti located at 1600-1700m). In relation to the climatic conditions of the area Cindrel Massif, there are good conditions for winter sports in the period from December to March, mainly on slopes located at 1500 m (slope Onceşti) from Păltiniş resort (SURDEANU, 2002).

CONCLUSIONS

As a result of global warming and hence mountainous climate, important changes occurred in the thermal regime and the rainfall with significant economic implications for skiing in the winter season in most of the mountain resorts. The most important changes occurred between 1986 and 2015, when it was registered a downward trend in the number of days with snow cover (especially after 2005), both in the period from November to April and in full ski season (December - March). For this reason, local authorities should make substantial investments to help the owners in equipping ski slopes of artificial snow and with government projects, dedicated to the development of tourism infrastructure.

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