THE ROLE OF SNOW IN THE FORMATION OF WATER FLOW IN SUCEAVA HYDROGRAPHIC BASIN

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Abstract. The role of snow in the formation of water flow in Suceava hydrographic basin. The hydrographic basin of the Suceava River is situated in the North-East sector of the Northern Carpathian Group from the Romanian Carpathians, more precisely, and much of the Suceava Plateau, a subunit of the Moldavian Plateau. The floods produced on the rivers in this basin were directly influenced by fallen liquid precipitations.
The study is based on the processing and interpretation of climatic data about the snow layer recorded throughout the period. Also, data on the floods in the Suceava River Basin were recorded at eight hydrometer stations, three of which are located on the main course and five are on the main tributaries. The analysed period for the snow layer and its influence on the water flow formation in the study basin during the period 1961-2015, focusing on the variation in snow thickness and length over the analysed period.
Finally, the influence of the snow layer on the drainage of the water and the drainage of the Suceava river basin during the analysed period with effect on large waters, floods and small waters was presented.

Keywords: snow, layer, basin, water flow, melting, periodic

1. INTRODUCTION

The Suceava River, a tributary of the Siret River, has a basin extending across the territory of Romania between the following geographical coordinates: 47°31' and 47°59' north latitude and 25°05' and 26°33' east longitude. This hydrographic basin is an asymmetric one with a strong development on the right side (Figure 1), and drains the eastern edge of the Northern Carpathian Group, passing through a contact sector (Marginea - Ciungi Piedmont) consisting of a succession the hills and depressions, and the lower basin is totally situated in Suceava Plateau. The Suceava River has a length of 173 km and an area of 2298 km^2, of which 13% is developed in the territory of Ukraine. The maximum altitude recorded in the basin is 1463 m at springs in the mountain trench and reaches 540 m at the point of spill in the Siret River.

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In the development of river water flow, an important role is played by the contribution of the melting of the snow layer. Determination of the quantity of snow intake is difficult to quantify, because this process interferes with parameters that are not monitored permanently, such as air and soil temperature and influences induced by slope values, slope orientation, vegetation presence, and so on.

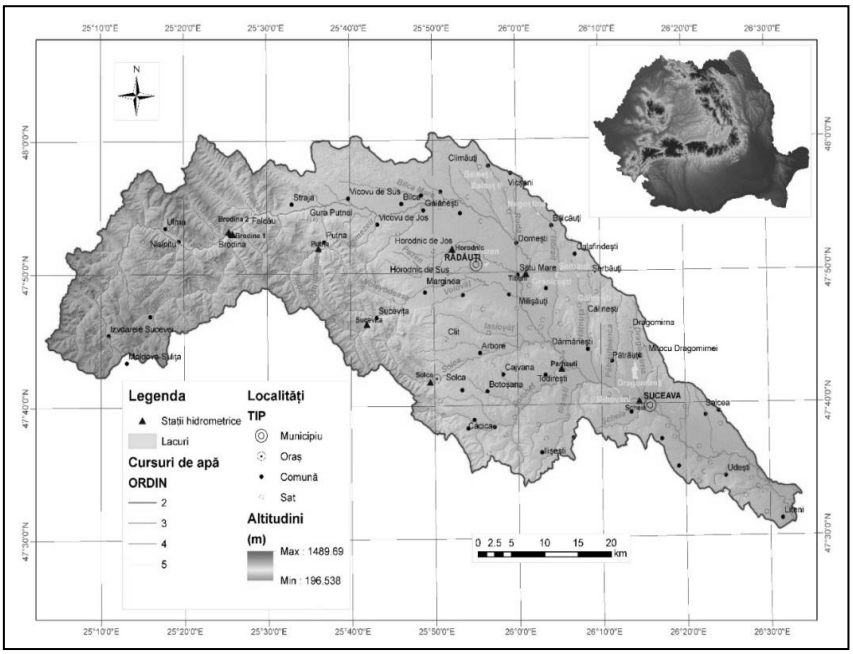

Fig. 1. Suceava hydrographic basin

Like every other climatic element, the snow layer is characterized by several parameters: temporal – snow cover duration (%, days), snow cover date, snow loss date, quantity – thickness of snow layer (%).

2. DATABASE AND METHODOLOGY

The database used in this paper includes meteorological data (solid precipitation, thickness of snow) obtained from the source: Birsan, Marius-Victor; Dumitrescu, Alexandru (2014): ROCADA: Romanian daily gridded climatic dataset (1961-2010) V1.0., National Meteorological Administration, Bucharest, Romania, two: 10.1594 / PANGAEA.833627. Hydrological data (maximum, average, level), obtained from ABA "Siret", SGA Bacau for 8 hydrometric stations, 3 of which are on the main course and 5 on the main tributaries.

The methods applied in the work are the standard ones, represented by bibliographic study, field study, collection, processing, interpretation and graphic representation of hydrological and meteorological data. A

With the help of Microsoft Excel, the graphical processing and graphical representation of the solid precipitation and flow rates required for a better presentation of the phenomena analysed in this paper was performed.

3. RESULTS AND DISCUTIONS

In order to analyze the thickness and the temporal length of the snow layer in the Suceava River basin, the most relevant time and quantitative parameters were calculated, including the occurrence and disappearance of the first and the last snow layers, its duration, the average monthly and average thickness and maximum.

Time parameters

Depending on the altitude, the snow layer persists more in the higher areas, with shorter hill and plain times. This is due to the longer persistence of negative temperatures at high altitudes. Table 1 presents the variations of these parameters in the basin of the Suceava River calculated for the period 1961 - 2015.

Table 1. Date of occurrence and disappearance of the first or last layer of snow

Station	Station altit. (m)	First snow layer			Last snow layer		
		First date	Average	Last date	First date	Ave-rage	Last date
Brodina	1016	14.10.2008	06.XI	16.12.1985	22.03.2009	21.IV	04.05.2010
Izvoarele Sucevei	910	28.09.1976	03.XI	17.12.1999	23.03.2009	25.IV	07.06.2010
Marginea	446	24.10.1990	15.XI	20.12.1999	03.03.2010	26.III	24.04.1996
Pârhăuți	300	26.10.1990	23.XI	26.12.1985	18.02.1989	24.III	18.04.1996
Suceava	296	26.10.1990	24.XI	26.12.1985	9.02.1976	18.III	18.04.1996

The first layer of snow occurs when the soil is cold enough to keep it. Table 1 shows that in the basin of the Suceava River the average date for the first layer of snow depends on the altitude and the longitude, including November at the end of the autumn, ranging from the first decade of November in the upper basin to the last decade of the month November in the lower basin, at the shed.

The extreme dates for the first layer of snow vary again, depending on the altitude. The high western mountain region is the one that reacts most quickly to the appearance of winter, the first snow cover appearing since the last decade of

September (Izvoarele Sucevei). In the plateau sector, where winter makes its presence felt much later, the snow layer may appear the fastest in the third decade of October. The latest snowfall date is recorded at all stations in the second and third decades of December, against the background of much warmer autumns, as they were in 1985 and 1999.

It can be observed that the altitude is also the one that influences the range of variation from the average. While in the plateau sector, the variation range is about 30 days, in the mountain sector it reaches 35 days, showing the longer cold period in the sector.

The disappearing date is another important element in analyzing the duration of the snow layer. It occurs during the spring, and can be stretched until early summer in the high mountain areas. The shorter the snowfall date, the greater the risk of overlapping snow melting in the upper high segments with the bigger waters in the lower sectors, causing mixed spring floods.

In the Suceava River Basin, the average snowfall disappears according to altitude. For the first time, it disappears from the plateau sector (the second and third decades of March, respectively), delaying until the third decade of April in the upper sector.

Extreme snow disappearance data show smaller variations than average over 30 days (compared with the higher snowfall variation), but - in the mountain sector there may be isolated cases when this variation occurs sea, and the snow layer may appear in May and even in the first decade of June (Suceava Springs). Two such very long winters were those between 2009/2010 (upper basin) and 1995/1996 (middle and lower basin) (Table 2).

Table 2. Snow layer duration (days)

Station	Average	Minimum	Year	Maximum	Year
Brodina	138.28	92	1989	168	1996
Izvoarele Sucevei	146.78	97	1989	175	1979
Marginea	113.66	61	1989	143	2010
Părhăuți	82.78	17	1988	126	1968
Suceava	78.22	10	1988	128	1962

The average annual snowfall interval is calculated as the difference between the date of appearance of the first snow layer and the date of disappearance of the last layer of snow. It is calculated in days.

In the Suceava basin, the average duration of this interval varies greatly, accounting for around 80 days (less than 3 months) in the lower basin, increasing to nearly 150 days (5 months) in the upper basin.

The extreme lengths of this layer are determined by local and punctual climatic conditions, especially in the case of minimum durations. From Table 3 it can be seen that the smallest times were recorded at all measuring points in the years 1988 and 1989, which were the most drought years in this river basin. This shows the direct relationship between the lack of precipitation - the decrease in the snow layer - the sharp decrease in the flow of the rivers. Minimum durations depend on altitude, reaching 10 days in the lower basin, up to 97 days in the upper basin.

Table 3. Average monthly snow layer duration (days)

Station	I	II	III	IV	V	VI
Brodina	30.5	27.62	26.72	8.6	0.28	0.04
Izvoarele Sucevei	30.76	27.72	28.74	11.38	0.46	0.02
Marginea	29.24	25.14	18.74	2.66	0	0
Pârhăuți	23.16	20.46	12.9	0.6	0	0
Suceava	21.96	19.56	12.02	0.58	0	0

Station	VII	VIII	IX	X	XI	XII
Brodina	0	0	0	2.76	13.7	28.06
Izvoarele Sucevei	0	0	0.04	3.84	15.26	28.56
Marginea	0	0	0	0.92	10.82	26.14
Pârhăuți	0	0	0	0.28	6.56	18.82
Suceava	0	0	0	0.26	6.42	17.42

The maximum duration of the snow layer is directly related to the amount of precipitation falling within that range, but also to the relatively low but not very low temperatures that will allow precipitation and snow cover to form. It can be noticed that in this hydrographic basin the year of occurrence of the peaks differs from one place to another, appearing in almost every decade of the study interval.

At monthly level we can see the variation of the snow layer in the basin. The longest snow cover is recorded in December - February. The month with the highest average values is January, when it is recorded in this study and the lowest atmospheric temperatures, keeping the snow layer intact for long periods. In the mountain and transition sector, almost the entire month of January the soil is covered with snow (29 - 30 days). In the plinth sector these values drop to 22 days. These are February (28 to 20 days) and December (between 28 and 17 days).

Between March and April, the duration of snow strain decreases considerably, becoming almost non-existent in May-June. This is due to the later occurrence of winter phenomena in this sector of the country (with Baltic

influences in N and N, and Eastern Siberian influences in E and SE) and their prolongation during spring. In April, the duration of the snow layer varies, on average, between 1 day (the plateau sector) and 12 days (the mountain sector). Larger variations occur in March, when the mountain sector records (on average) up to 29 days with snow cover (almost the entire month of March is covered with snow). In the lower basin, snow cover this month lasts about 12 days, which is a 17-day difference where the melting of snow in the mountain sector can greatly influence leakage in the lower basin.

During the months of June - August, the snow layer is almost non-existent, with only occasional occurrences during June in the mountain basin (Table 4). In September, the snow layer appeared only in the mountain sector (Izvoarele Sucevei), in October recording an average of up to 4 days with snow. November is best represented, with values ranging from 6 days (in the lower basin) to up to 15 days in the upper basin.

Table 4. Monthly variation of snow layer maximum duration (days)

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Brodina	31	29	31	24	4	1	0	0	0	12	30	31
Izvoarele Sucevei	31	29	31	30	4	1	0	0	2	14	30	31
Marginea	31	29	31	17	0	0	0	0	0	8	28	31
Părhăuți	31	29	31	8	0	0	0	0	0	6	25	31
Suceava	31	29	31	8	0	0	0	0	0	6	25	31

Another element that shows how intense winter is in this studyy is the maximum monthly snow cover time. It reaches the maximum during the winter months at all stations, maintaining it at maximum values in November and April in the upper basin, slightly decreasing with the decrease in altitude.

Quantitative parameters

Between the quantitative parameters of the snow layer, the most important is its thickness, with important implications both in the water regime of the water flow in the basin (influenced by the intake of water from the melting of snow, but also the reserve of water accumulated in the soil), but also (agriculture), hydro-technical facilities, water supply etc. The thickness of the snow layer varies depending on the altitude, in mountain areas it is possible to maintain a higher layer thickness due to favourable weather conditions.

Monthly average thickness. Although the highest snow cover is recorded in January, the highest thicknesses are recorded in February (even March in the mountain sector) (Table 5).

Table 5. Average monthly thickness (cm) of snow layer

Station	I	II	III	IV	V	VI
Brodina	27.47	**39.70**	37.51	7.22	0.04	0.00
Izvoarele Sucevei	32.31	45.31	**47.43**	12.00	0.11	0.00
Marginea	17.95	**21.59**	15.49	1.04	0.00	0.00
Pârhăuți	8.07	**9.53**	6.42	0.21	0.00	0.00
Suceava	7.42	**8.80**	5.97	0.21	0.00	0.00

Station	VII	VIII	IX	X	XI	XII
Brodina	0.00	0.00	0.00	0.41	4.55	15.02
Izvoarele Sucevei	0.00	0.00	0.00	0.67	5.52	18.43
Marginea	0.00	0.00	0.00	0.08	2.89	9.71
Pârhăuți	0.00	0.00	0.00	0.01	1.17	3.90
Suceava	0.00	0.00	0.00	0.01	1.13	3.59

This is due to the persistence of negative temperatures until March, which favours the massive accumulation of snow. The highest values of the thickness of the snow layer are registered at the Izvoarele Sucevei, where, in February - March, the thickness is maintained at 45 and 47 cm respectively. With the decrease of the altitude, the thickness of the snow layer decreases, reaching up to 9 cm in the lower section. The variations in mean snow thickness are lower in the plank sector (6,5 cm), but these increase significantly, but they increase significantly with the transition to the mountain sector, reaching 34 cm in the highest part of the basin.

Average seasonal thickness. From an antimicrobial point of view, the highest thickness of the snow layer is recorded in winter, with higher values in the plateau sector, where the winter layer accounts for more than 65% of the total percentage of its presence. In the mountain area this percentage is lower, reaching 55% (Figure 2).During the spring, due to the lower temperatures during this period, the snow layer maintains much more in the mountain area (30% of the cases), in the hill area the percentage is only 21%. Autumn shows equal relative values throughout the study, and the summer snow layer is non-existent, appearing only in very isolated cases in the mountain sector.

If the average thickness of the snow layer shows the overall variation of this, the maximum / minimum thickness is determined by exceptional climatic conditions, with very low droughts for minimum values or long and very cold winters for maximum values. The harshest winters in Romania during the study period (1961 - 2015) were 1962/1963, 1984/1985, 1995/1996.

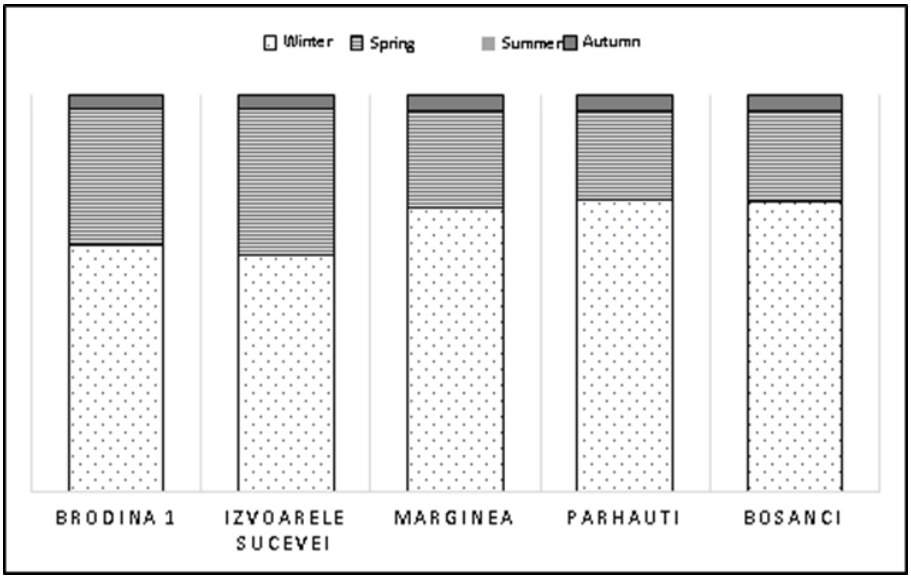

Fig. 2. Seasonal variation of snow layer thickness (%)

From Table 6 it can be noticed that the most obvious winter was the one between 1994/1995, in these years the highest values of the thickness of the snow layer were recorded in the entire hydrographic basin. These years occur with maximum values in more than half of the cases.

The highest values of the thickness of the snow layer are recorded in March throughout the basin, with values increasing from 53 cm in the plateau sector to 152 cm in the mountain sector (Table 6). It follows that April, with thicknesses of the snow cover varying between 50 cm and 115 cm, followed by January and December. The much higher snow depths in March - April are specific to the mountain areas and to the eastern cliffs of the Eastern Carpathians, where snow melting takes place much later than in the western part of the country, where at altitudes similar to the thicknesses. Higher rates are recorded in November - January (Clima României, 2008).

Table 6. Maximum monthly thickness (cm0 of snow layer and the year of appearence

Station	I	II	III	IV	V	VI
Brodina	82.00	100.00	**140.00**	106.00	9.00	3.00
Year	1995	1998	2010	1995	2010	2010
Izvoarele Sucevei	86.00	104.00	**152.00**	115.00	15.00	4.00
Year	1995	1995	2010	1995	1981	2010
Marginea	67.00	81.00	**83.00**	84.00	0.00	0.00
An	1995	1995	1995	1995	0	0
Pârhăuți	41.00	52.00	**53.00**	50.00	0.00	0.00
Year	1962	1995	1995	1995	0	0
Suceava	43.00	53.00	**54.00**	50.00	0.00	0.00
Year	1962	1995	1995	1995	0	0

Station	VII	VIII	IX	X	XI	XII
Brodina	0.00	0.00	1.00	19.00	44.00	81.00
Year	0	0	1969	2004	1994	1994
Izvoarele Sucevei	0.00	0.00	5.00	20.00	45.00	88.00
Year	0	0	1994	2004	1994	1994
Marginea	0.00	0.00	0.00	7.00	35.00	62.00
An	0	0	0	2002	2000	1994
Pârhăuți	0.00	0.00	0.00	3.00	21.00	32.00
Year	0	0	0	1970	1980	1994
Suceava	0.00	0.00	0.00	2.00	20.00	35.00
Year	0	0	0	1996	1980	1994

4. CONCLUSIONS

The snow layer in the Suceava River basin influences the drainage of the water and consequently the drainage regime during the cold period of the year, especially in winter and early spring.

In winter, negative air temperatures preserve the snow layer, causing frost on rivers and removing large amounts of water from the circuit, the differences between the sub-basins being given by the exposure to the mass of air and the location of the mountain range or of the plate, causing the occurrence of small water periods due to the storage of water in the snow layer. In the Suceava basin, the low winter water period is the most intense of the whole year, the water flow in this season barely approaching 15% in the plateau sector.

The snow layer plays an important role in the formation of large water from the beginning of the spring, which is the most frequent during this season, and the mixed floods occurring in March and April. Effects of snow cover are less felt during autumn, especially at the end of November, when its thickness is reduced, and the presence of small floods and water is smaller.

REFERENCES

1. Croitoru, Adina-Eliza, Excesul de precipitaţii din Depresiunea Transilvaniei, „Casa Cărţii de Ştiinţă" Publishing House, Cluj-Napoca, Romania, 2006
2. Musteţea, A., Viituri excepţionale pe teritoriul României. Geneză şi efecte, Tipografia SC „ONESTA COM PROD 94 SRL, Bucureşti, Romania, 2005
3. Naggle, G., Hazards, Nelson Thornes Publisher, Oxford, Great Britain, 1999
4. Porcutan, Adriana (2017) – Particularities of air temperatures' seasonal trends in Suceava Hydrographic basin, în "Riscuri și catastrofe", Editor V. Sorocovschi, Nr. 2/2017, pp. 51-60
5. Porcutan, Adriana, Sorocovschi, V. (2017) – Particularities of the seasonal water flow regime trends of the rivers from Suceava hydrographic basin, în "Riscuri și catastrofe", Editor V. Sorocovschi, Nr. 1/2017, pp. 113-122
6. Porcutan, Adriana (2016) – The particularities of minimum flow on the rivers from Suceava hydrographic basin, în "Riscuri și catastrofe", Editor V. Sorocovschi, Nr. 2/2016, pp. 65-76
7. Porcutan, Adriana (2016) – Particularities of periods with maximum water flow on the rivers from Suceava hydrographic basin, în "Riscuri și catastrofe", Editor V. Sorocovschi, Nr. 2/2016, pp. 89-102
8. Porcuțan, Adriana (2015) - Seasonal flow regime for the rivers inside Suceava hydrographic basin, în Analele Universității Valahia din Târgoviște, Seria Geografie, Tom 15/2015, Volum 2, pp. 94-100
9. Porcutan, Adriana, Sorocovschi, V., Popa, Lăcrimioara (2015) - The role of rainfalls in floods generation from Suceava river basin. Case study: the flood from Solonet River, July 2008, în SGEM2015 Conference Proceedings, ISBN 978-619-7105-36-0 / ISSN 1314-2704, June 18-24, 2015, Book3 Vol. 1, 689-696 pp
10. Porcutan, Adriana, Sorocovschi, V. (2015) - Particularities of floods in Suceava river basin, în SGEM2015 Conference Proceedings, ISBN 978-619-7105-36-0 / ISSN 1314-2704, June 18-24, 2015, Book3 Vol. 1, 485-492 pp
11. Sorocovschi, V., Riscuri hidrice, in „Riscuri şi catastrofe", "Casa Cărţii de Ştiinţă" Publishing House, Cluj-Napoca, Romania, 2002
12. Sorocovschi, V., Hidrologia uscatului, "Casa Cărţii de Ştiinţă" Publishing House, Cluj-Napoca, Romania, 2010
13. *** , Geografia României. Vol. III, „Academia Republicii Socialiste România" Publishing House, Bucureşti , România, 1983
14. ***, Geografia României. Vol. IV , „Academia Republicii Socialiste România", Publishing House, Bucureşti , România, 1987
15. http://www.rowater.ro/EPRI%20Rapoarte/RO10_%20PFRA_Report_%2020130531. pdf
16. http://www.wetterzentrale.de/topkarten/fskldwd.html
17. http://www.tulane.edu/~sanelson/Natural_Disasters/riverflooding.htm