THE INFLUENCE OF OROGRAPHY ON THE SURPLUS PLUVIOMETRIC REGIME OF THE SEBEŞ BASIN

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ABSTRACT – The Influence of Orography on the Surplus Pluviometric Regime of the Sebeş Basin. The paper presents important genetic factors which influence the precipitation regime in the Sebeş Basin. Our main focus is the role of the basin's orography; in general. its exposition is northern and located on the northern macroversant of the Parâng group. its altitudinal structure influences the configuration of the storeys. the summits and valley chutes influence precipitation. in terms of frequency and location. The pluviometric regime is characterized by an analysis of average monthly and yearly precipitation. and of excess precipitation for a period of at least 20 years. The deviations of the largest quantities of yearly precipitation are due to local altitude-related particularities. relief fragmentation and versant exposition in the general atmospheric circulation. The effects of excess precipitation during the analyzed periods are also presented.

Key words: pluviometric regim, surplus of precipitations, orography, Sebeş Basin.

1. INTRODUCTION

Atmospheric precipitation provides the raw material for the water cycle and. given its regime, is a crucial meteorological-climatic factor which influences both the natural environment and anthropic activity. The precipitation regime is extremely variable in the Sebeş Basin in terms of quantity, intensity, duration and frequency (Bogdan 2008). The active surface is of crucial importance in the local-precipitation regime through thermobaric convective processes, through association with other genetic factors, especially with air circulation. The relief has a decisive role, both through the orographic configuration of the Carpathian chain, involved in the reception, deformation and/or deviation of the western, north-western, south-south-western circulation which characterizes this basin, as well as through the local morphographic and morphometric elements, typical of the Sebeş Basin.

The analysis of the precipitation regime takes into consideration the quasi-central geographical position in the Romania's territory, and the location of the basin on the northern versant of the Meridional Carpathians i.e. of the Parâng Group, at the junction of several types of air circulation masses. This position amplifies the role of orography in determining the territorial diversity of the climatic features and variability of climatic phenomenon, especially precipitation. The analysis of pluvial regime was effected in a comparative manner, with a

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particular interest for the differentiation between each sector of the basin: the upper (Carpathian) and the lower (depression). The regime particularisation is based on the analysis of the highest annual and monthly amounts of rainfall at Păltiniş, and Sibiu meteorological station, supplemented with data produced by the hydrometric stations Frumoasa and Valea Mare on the superior Sebeș-river basin; on the analysis of the annual rainfall surplus recorded against multi-annual figures; on the analysis of the monthly rainfall surplus in said years against multi-annual monthly mean figures. The period under analysis spans at least 20 years. certain differences being the case. as follows: Păltiniș (1970–2007); Frumoasa (1990–2006); Valea Mare (1985–2006); Sebeș (1980–2007).

2. RELIEF – AN INFLUENCING FACTOR OF THE PLUVIAL REGIME

The climate of the hydrographic Sebeş basin is not essentially different from the regional general climate, as it is subjected to the same rules deriving from it altitude and the circulation of the air masses. Being a component part of the depression and the Carpathian space in the centre of Romania, the Sebeş Basin meets the climatic requirements of the continental temperate regime which induces diversification elements introduced by its northern exposition and position in relation to the dominant western circulation, the location of the summits and valley chutes in relation to the air masses and solar radiation and altitude levels (Costea. 2005; Bogdan. 2008).

First, we note the **role of orographic basin** of the Meridional Carpathians transposed in the limits of the Sebeş basin on levels between 2244 m in Cindrel Summit and 216 m at the confluence with Mureş river, the major relief energy of over 2000 m, in the massiveness and wide opening of the main interfluves which descend gradually towards north and in the predominantly northern orientation. Within these circumstances and given the general south-northern inclination and the general air circulation, the Sebeş basin:

- through southern mountainous summits, blocks the flow towards south of the masses of air drawn by the western and north-western circulation and in addition;
- receives the advection of maritime-air masses related to the alternating activity of the Azores anticyclone and the Icelandic cyclone, of the oceanic cyclones drawn to their extremities, which determines the pluviometric maximum in the summer (143.8 mm in June in and 70.4 mm in July in Sebeş) (Dragotă. 2006); in the cold season. because of the Scandinavian anticyclone, there are early and late snows;
- is influenced by local dynamic processes – the Carpathian orographic cyclogenesis, associated with the northern circulation, which determines an unfavorable weather and significant precipitation (1998. 1999. 2001. 2005 etc.) (Bordei. N.I.. 2008);

- may be affected by the south-south-western circulation through the activity of Mediterranean cyclones travelling towards north-north-east and which determines a high volume of precipitation in the warm season – short and long torrential downpour (maximum in 24 hours), and in winter warm rains melting the snow (55.4/03.01.2004);
- may be traversed by Tropical dry-air masses from Africa, because of the progress of the Azores anticyclone towards south and the latency of the Mediterranean cyclones, which determine a precipitation deficit and dryness in the inferior basin, in summer, and early fall (Secaş basin); these winter advections cause dryness and lack of precipitation, snow and dry and mild winters;
- in winter, there are large quantities of snow, there are snowstorm, given the correlated activity of Eastern-European anticyclone (cold and dry air) and the Mediterranean cyclones (hot and humid air).

As a consequence, the altitude levels and the position of the Sebeş basin emphasize the role of orographic basin in front of the air masses and on the other hand determine the characteristics of the pluviometric regime and the associated intensity of pluvial hazards.

Secondly. the altitude of the basin and its overlapping with two major relief units – the Meridional Carpathians and the Transylvanian Depression, determine a differentiation on sectors of the climatic characteristics: the superior and medium basin – characterized through a mountainous climate and the inferior basin characterized through a low-hill and plateau climate, with precipitation variations. The leveled structure of the relief determines a leveled climate, especially in the mountainous areas and in morphoclimatic levels. Each morphoclimatic level is characterized by the homogeneity of the values of climatic elements and by climate phenomena determined by the diversity and frequency of air-masses advections and orography. Moreover, there is another characteristic feature of the Sebeş basin, i.e. the almost complete overlapping of the mountainous climate with the forest topoclimate (90% of the Carpathian basin is forested). In these circumstances, the amount of precipitation is differentiated according to the altitude.

The orientation of the summits and valley corridors, their convergence to the partially-transversal axis of the Sebeş facilitate the air circulation in the basin through channeling on the concave shapes or flowing across the positive forms, from north to south or south to north depending on the advection. Frequently, the air circulation leads to direction shifting, followed by dislocation or interruption of pluvial processes and their replacement (Bogdan, 2008). The high relief energy on the valley corridors of the Sebeş River and its tributaries (200–600 m/km^2), the verticalness of the versants and the thermobaric characteristics which vary depending on altitude, determine local air circulation phenomena during the day (mountain-valley winds) accompanied by air condensation processes and huge precipitation especially on summer days in the Carpathian basin. The steep versants of the valley between Oaşa and Săsciori and the mountainous summits nearby situated on altitudes of 1700–1200–1000 m represent a "condensation ceiling" (Dragotă, 2006; Bogdan, 2008) causing huge precipitation. When the cyclone activity is intense there is abundant precipitation, the average yearly/daily values reaching maximum values.

Another characteristic of the relief in the Sebeş basin is the presence of alternating defiles and depression intra-mountain bassinets, and also the overlapping of the inferior basin with the Apold Depression and the confluence with the Mureş river valley in Alba Iulia through a large opening towards north-west and west. Thus, the most representative role in mountainous basin, with respect to the precipitation regime, is played by the intra-mountain depression Oaşa, whose concave surface occupied almost entirely by the Oaşa storage lake, in addition to the summits nearby, induces thermal differences and surplus humidity. The closing of this depression toward north, through the Sebeş defile, and its wide opening towards south facilitates the accumulation of air masses drawn by the south-western and southern circulation which crosses the Meridional Carpathians (humid Mediterranean and dry tropical. as the case may be). The configuration of the summits in the superior sector of the basin facilitates the entrance of the air into this depression: the summits Ştefleşti – Piatra Albă – Sălanele – Smida Mare – Vârfu lui Pătru, with an altitude of 600 m, from east to west. The lowest altitudes are present in the Tărtărău (1680 m) and Sălanelor saddles. The maximum extension is at altitudes of 1680–1800 m. In the northern boundary of the basin, the concave shape of the Apold Depression and the opening towards the Mureş valley allows an easier advection of western and north-western air masses. However, the pluviometric regime in this sector is subordinated to the reduced altitude and submountain position, in the northern sector of the Cindrel Mountains and in the south-eastern sector of the Trascău Mountains where föhnal influences are apparent: in summer a dry climate, even drought (depending on the anticyclone activity) and in winter related passing phenomena (Bogdan, Marinică, 2007).

3. AVERAGE PRECIPITATION AMOUNT

The monthly evolution of precipitation in the depression and mountainous areas reveals a directly proportional ration between altitude and the average precipitation amount. These are 489.9 mm/year in the inferior basin near Sebeş, of 584 mm/year at cca. 420 m altitude, 890 mm/year at 1400 m (Păltiniş – 896.6 mm) and of 1222 mm/year at 2000 m altitude, the average precipitation gradient being of 42 mm/100 m. The vertical gradient is not very rather variable (Costea. 2005). This is around 53 mm /100 m in the depression and plateau sector and then it decreases in the inferior Carpathian storey to 30 mm/100 m, and above 1400 m the values being of 57 mm/100 m. In the altitude levels represented by the meteorological stations where the data was recorded. the gradient does not present significant differences; the value of 30 mm/100 m in the inferior mountainous level are due to the föhnal manifestations at the foot of Cindrel Mountains.

The monthly amounts vary considerably with the general atmospheric oscillation and the intensity of local precipitation generating phenomena. The monthly distribution presents a continuous increase from January to June, when the maximum is reached, and then a decrease until January when the minimum is reached. The highest monthly average amounts are recorded in the depression in June–July, maximum in June, and the minimum in January–February. In the mountain area, the highest values are recorded in May–June, the maximum in June, and the minimum in February–March. In the depression area there is also a secondary minimum in October–November, because of oceanic influences.

The precipitation in October–March represents around 36% of the yearly values, at an altitude of 2000 m. The distribution on seasons is equally suggestive and maintains the same ratio with the altitude. The largest amounts are recorded at high altitudes and in summer (over 600 m), the maximum is in June, i.e. 65–70%. During the cold season, the precipitation values reach 30–35% (Sebeş – 167.8 mm and Păltiniş 270.9 mm). In spring. because of the cyclones in the Atlantic and the masses of humid air in Central Europe, these affect higher areas and cause rich precipitation: 220 mm at 1000 m and 270 mm at 2000 m. i.e. 27–28% of the entire quantity of precipitation in the basin. June is the most humid month of the year, and in the fall the amount of precipitation decreases significantly, because of the latency of cyclone activity and the intensification of anticyclone activity.

The seasonal concentration index is also relevant for the pluviometric regime in the Sebeş basin (calculated as a ratio of the total precipitation between May and June and 1/3 of the total precipitation from August to April). This index decreases with the altitude. The highest values are recorded at around 400 m (2.14) and decreases to 1.97 at 2000 m. The value of 1.78 obtained at Sebeş is lower than the value calculated for higher altitudes and is the result of the small amounts of precipitation at Sebeş and the occurrence in different months of precipitation maximum values. In addition, the sheltered location of the Secaşul Mare basin, protected from the masses of humid air and föhnal manifestations have an important role in decreasing the precipitation season concentration index.

4. THE HIGHEST ANNUAL PRECIPITATIONS

The distribution of the highest annual precipitation amounts in the Sebeș-river basin is under the influence of the altitude as well as of the northern position of the basin. The pluvial excess is due to masses of temperate oceanic masses (i.e. Atlantic cyclones), which are frequent during the summer as well as during transition seasons. Such masses of cold and relatively wet air are set in motion at the periphery of the Azores High (Moldovan, 2003) and permeate the basin from W-NW. They generate an abundance of rains in the summer and snows (or snow storms) during the winter. Although, great amounts of rainfall are due to the masses of tropical air – warm and wet, from Mediterranean Sea – that arrive in the basin area from S-SW. Upon passing the summits of Parâng and Șteflești, those air masses generate if occurring in the winter, sudden heating and abundant snowfall or even rainfall, whereas in the summer time they generate unstable weather and abundant precipitations (Costea, 2005).

Therefore, throughout the Carpathian basin, for as long as the records were made (1970–2007) in the Păltiniş station, the annual amounts of precipitations exceeded the multi-annual average figure (i.e. 970.84 mm) in 19 out of the 37 years, of which in 17 years the excess was above 1000 mm p.a. In most of the cases (twelve), the surplus measured against multi-annual average amounts was in the range of 100–500 mm p.a. (see Table 1).

Table 1. ***The highest annual and monthly precipitation amounts***

	PALTINIS 1454 m	year	SEBES 240 m	year	FRUMOASA p.h.	year	VALEA MARE	year
I	106.2	1976	46.8	2004	67.8	2000	78.3	1987
II	85.7	2005	52.6	1999	75.3	1992	97.2	1985
III	122.6	1988	86.5	1988	112.4	1997	116.1	1988
IV	162	1982	101.4	2004	178.7	1997	181.9	1997
V	251.3	1975	113	1984	149	1991	151.9	1995
VI	312.1	1975	123.7	2001	207	1998	165.1	1985
VII	314.3	1975	158.2	1991	226.6	2005	195	1999
VIII	322.6	2007	159.6	2006	203.6	2005	207.5	2006
IX	208.6	1978	106.8	2001	197.9	2001	156.8	2001
X	223.5	1972	103.7	2001	108.6	1998	98.5	2003
XI	122.6	1995	94	1983	125.7	2001	138	1995
XII	102.6	1990	87.6	1999	129.5	1999	148	1995
Ann.	1477	1975	742	1985	1129.2	2001	1087	1995

The high precipitation amounts triggered a humidity excess in the soil, as well as in the geological substrata, determined the re-activation of the slope and riverbed processes, and started new ones. The torrential phenomena and the creation of considerable debris cones on the limits of torrent basins generated forests damage, roads and bridges, and households damage when these were situated on slopes or on the bottom of valleys, whereas traffic on the Sebeş valley upstream of Şugag was obstructed every year that encountered rain surplus. The records from the hydrometric stations of Frumoasa and Valea Mare indicates the occurrence of high amounts of precipitations also on the bottom of Carpathian valleys, not just on the northern slopes that are exposed to oceanic air movement. For instance, in Frumoasa, over the period under analysis, the precipitations exceeded the multi-annual station records (i.e. 872 mm) by more than 150–250 mm; here too the 1.000 mm p.a. mark was exceeded in just 4 cases out of 17 (namely 1995, 1997, 1998 and 2001), by 50–150 mm (Costea. 2004).

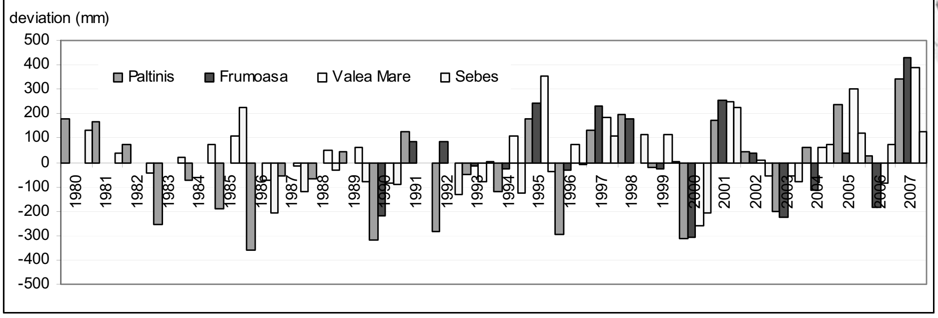
At the Valea Mare station, during the 20 year period of data recording, the multi-annual average figure (733.1 mm) was exceeded in 14 cases, of which the surplus was in 7 cases in the range 100–350 mm (1985, 1994, 1995, 1997, 1999, 2001 and 2005) (see Figure 1). The most important amounts recorded on the corridor valleys of the Sebeş and its tributaries are the outcome of cyclone and frontal influence being associated with the entrainment and orographic local conditions (Bogdan, 2008), determined by the development in altitude, relief energy, declivity etc. In this case, the steep slopes of the Sebeş gorge and the tributary valleys count as a “condensation ceiling”.

Table 2. ***Annual average amounts of precipitations and years with surplus***

Year	PALTINIS 1450 m	FRUMOASA p.h.	VALEA MARE p.h.	SEBES 240m
1980	1152			649.5
1981	1136			555.3
1982	1046.4			470.6
1985	779.1		840,9	742
1989	1015.2		795.5	440
1991	1097.5	957.1		512.2
1995	1151	1117.6	1087.3	481.6
1997	1099.6	1106.5	914.9	626.2
1998	1169.6	1049.3		630.1
2001	1141.1	1129.2	983.3	741.9
2002	1012.2	912.3	741.7	459.2
2004	1033.5	759.7	794.1	589.6
2005	1205.1	909.7	1036.8	638.3
2006	1000	686.4	647.6	589.3
2007	1310.2			640.3
multiannual average	970.84	872.60	733.1	516.92
maximum	1310.2 / 2007	1129.2 / 2001	1087.3 / 1995	742 / 1985

In the lower basin, the highest annual precipitation amounts in the years observed occurred in 13 of the 27, when the mean multi-annual figure (516.92 mm) was exceeded by 20–225 mm (see Figure 1). In 6 cases, the amount of 600 mm p.a. was exceeded. The maximum precipitation amount was recorded in 1985 (742 mm). The years with the most abundant precipitations are recorded a discrepancy in altitude between the station in the depression and those in the mountains. The frequency of the humidity surplus is 2–4 years, alternating years of normal or lower-than-average humidity. The data on display show that the most important surplus is recorded where the potential for precipitations is the most important, namely in the mountainous areas, unlike the depression areas, where the surplus are less important but also the potential for precipitations is reduced on the whole; the fact was signalled upon by Bogdan and Niculescu (1999). The biggest annual amounts of precipitations are recorded on different quantitative levels at the four stations (also stressed by Moldovan, 2003 and Croitoru, 2006 for the Transylvanian Depression), with a higher frequency over the last two decades, when the most important surplus occur, and the pluvial hazard is amplified by virtue of the consecutive occurrence of 2–4 years (1995–1999, 2001, 2005, 2007 in the Carpathian basin; 1997–1998, 2001, 2004–2007 in the depression basin) (see Figure 1). The precipitation surplus did not occur simultaneously over the whole of the Sebeş basin. It was first initiated in the mountainous basin (1988–1989, 1991–1992, 1995–1998), shifting to lower altitudes (over 1997–1999). The precipitation surplus was also the case in 2001–2002 and 2004–2007, with the draught of 2000 and 2003 in between.

Fig.1 The deviation of annual amounts of precipitations from the multiannual average amount in the Sebes basin



5. THE HIGHEST MONTHLY PRECIPITATION AMOUNTS

The highest monthly precipitation amounts recorded during the observation intervals in the Sebeș basin were greater than the mean multi-annual monthly figures by 20–100 mm for the Sebeș station, and by 50–200 mm for the Păltiniș station. The surplus of the highest monthly average figures as taken against the average multi-annual monthly figures was 50–75 mm in the case of the upper basin, and 20–30 mm during winter months for the lower basin. The maximum surplus were recorded in the upper basin during the summer, and amounted to 100–200 mm, whereas in the lower basin they occurred in the spring and the summer and measured 50–100 mm.

The highest average monthly figures were recorded in different years, also on different levels of altitude (see Table 1); they exceed the multi-annual monthly average figures two or three times. The precipitation surplus occurs during May–September, throughout the basin. The highest records occurred in August in Păltiniș (322/2007); Valea Mare (207.5/2006); and Sebeș (159/2007) – not in June or July, as one would expect. The highest figures were recorded in Păltiniș, also in August, for three years in a row (2005–2007), while in the other years when records were made, the highest were June, July, and August. In Sebeș, in the lower basin, the monthly maximum was reached in 5 cases in August (1983, 1989, 1997, 2006, 2007); in 8 cases in July (1980, 1982, 1991, 1993, 1999, 2003–2005); in June in most cases recorded; but also in September (1995, 2000). A higher frequency of the maximum monthly average figures during the last ten years has been recorded, among which years of double (or more) figures against the multi-annual average monthlies are 2001 and 2006 (June–September); 2003 (July, September–October); 2005 (April–August); 2006 (March–August); and 2007 (May, July–November).

6. CONCLUSIONS

The periodical and non-periodical variability of the general atmospheric motion during the period under scrutiny resulted in the Sebeș-river basin, in some years, into exceeding the average multi-annual precipitations and a humidity surplus. This phenomenon is particularly specific for the Carpathians, as well as for the lower basin of the depression area. The occurrence of the highest yearly amounts is in coincidence with the atmosphere dynamics, but can as well be amplified and preserved by the characteristics of the active surface (Bogdan and Niculescu, 1999). As a consequence, in the Sebeș-river basin, the humidity surplus is intimately connected with the oceanic and Mediterranean cyclone activity, as well as the morphometry of the basin and certain local elements.

The climatic layering and the exposure of the slopes are such that impose certain differentiations as far as the conditions for the highest annual amounts of precipitations are concerned. Although the distribution of the maximum monthly average figures varies throughout the year in the period under analysis, the richest month in terms of precipitations in the Sebeș basin is June for the higher Carpathian basin and for the mountainside level, and July for the valleys corridors and the lower basin. We also call attention to the abundance of rainfall during March–April, at the same time with the melting of the snow, which is likely to increase the water surplus in the soil and the geological substrata, and generates spring freshets, especially in the intra-Carpathian depressions along the valley of the Sebeș river and its tributaries, or in the Sebeș-Apold Depression area. The effects of such phenomena consist of the occurrence and re-occurrence of geomorphological and hydrological phenomena, the erosion of soils by torrentiality and ravening, the destruction of spontaneous vegetation and cultivated fields because of the flooding.

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