Climatic features of the Muscel Valley (Buzău Subcarpathians, Romania) as from the registered data during 1961–2003

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Introduction

The overall climate of Romania is temperate continental of transition bearing different regional features such as: mountain conditions over the high relief brought by the cold air masses from the sarmatic region or steppe features in the plains. The general climate is determined by many factors, the most important being its geographical settings. In fact, because it extends over 5 degrees of latitude, Romania registers a 3°C thermic difference between its northern and southern regions.

The Carpathians also play an important role in the climatic zonation separating the north-western area, characterized by an oceanic influence, from the eastern one, where continental features are more evident. Another important factor is the Black Sea, which exerts a thermic regulation effect over the south-east of the Country where the Buzău Subcarpathians are located. Here, fairly mild Winters and cool Summers are typical, moreover, the climate of this region is dominated...
by air masses coming from north/north-east during Winter, when the Siberian anticyclone arrives in Transylvania, while in Summer western masses prevail (Bogdan et al., 1980; Bogdan, Mihai, 1977; Neamu, 1980).

The Buzău Subcarpathians have been studied by various authors, all underlining the intensity and variety of the present-day slope processes classifying almost 85% of the slopes as unstable (Bălteanu, 1971, 1983, 1994; Bălteanu, Dinu, Cioacă, 1996; Dinu, Cioacă, 1998). Among the major factors that generate or facilitate the development of mass movements and erosion processes, authors indicate the less erosion-resistant lithology, the neotectonic movements (0.5-1 mm/y), the strong earthquakes that affect the entire Vrancea region, and the intensity of rainfall. Starting from these researches, the present paper, a climatic study of a small catchment located in this area (Muscel valley) (Fig. 1), could represent a contribution for future studies focused on the relationship between climate and mass movements in this region.

The hydrographic basin of the Muscel river, tributary on the right of the Buzău, covers an area of about 19.70 sq km. Its borders are given by a range of hills, among which Vârful Pătârlagele (908.7 m), Piatra Scrisa (754.3 m) and Vârful Catnei (790.9 m) are the highest. As far as their geology is concerned Oligocene flysch formations (Kliwa sandstone) mount to almost 33% of the basin’s surface, while the rest mostly consists of highly folded and faulted Miocene and Pliocene marls, clays, sandstone and sand (Bălteanu, 1983).

The data analysed in this research were recorded by the thermopluviometric station located in the final sector of the Muscel river (Pătârlagele) over the period 1961–2003. It consists the daily recorded maximum and minimum temperatures, monthly precipitation and extreme rainfall events. The August temperatures for 1961 are missing so we considered them to be equivalent to the average of the following August months. According to WMO current climate is defined by the mean the meteorological features monitored
in a given location for the past 30 years (normal values). The choice of this conventional time length results as a compromise of the necessity of considering a sufficiently long period in which the climatic conditions are defined and stable, keeping in mind at the same time the variations of the climatic features given by an excessively long interval (Rosini, 1988).

The study series record 43 years. This is not much longer than the conventional period therefore we consider it representative for studying the climate of the area.

In the present work, the results of air temperature, precipitations and extreme rainfall events analysis are presented. Moreover, the Thorthwaite’s method was used to obtain the water balance and the climatic classification of the studied area.

**Air temperatures**

The air temperature study is based on the analysis of the data recorded at Pătârlagele station between 1961 and 2003. Besides daily temperatures, the mean monthly, seasonal and annual temperatures were calculated and analysed. The region has a mean annual temperature of 10.4 °C. The coldest month is January, with a mean temperature of −0.5 °C; this value is below 0.0 for most of the studied years. The warmest month is July, with a mean temperature of 20.6 °C. The annual thermic range is 21.1 °C varying from 23.0 °C, where we consider the mean of maximum temperatures, to about 19 °C if we consider the mean of minimum temperatures. (Tab. 1).

The mean temperature amplitude is 2.8 °C, representing the difference between the mean temperature of the coldest year (1976 with 8.8 °C) and that of the warmest years (1989–1994 with 11.7 °C).

**Winter temperatures.** After the analysing the maximum, minimum and mean temperatures of the Winter months, the features of this season were examined concerning some parameters normally used in climatology, such as frost days (number of days with Tmin = 0 °C), maximum number of consecutive frosty days, number of days with Tmax = 0 °C and the absolute minimum temperatures. (Pinna, 1977) (Tab. 2).

The mean Winter temperature is 0.4 °C and ranges from −3.3 °C (1963) to 3.3 °C (1966), the mean value of minimum and maximum temperatures are −4.2 °C and 5.0 °C respectively. The number of days with Tmin = 0 °C, which are on average 133.1 per year, varies from 81 (1966) to 136 (1989), while the number of days with Tmax = 0 °C ranges between 3 (1989) and 46 (1985).

1963 and 1985 registered the coldest Winters: these years recorded the absolute minimum temperatures of the study period, −25.5 °C (January, 23, 1963) and −24.6 °C (January, 17,
1985. Moreover, 1985 had the maximum number of consecutive frost days (76) and the maximum number of days with $T_{\text{max}} = 0^\circ\text{C}$ (46). The frost days and the days with $T_{\text{max}} = 0^\circ\text{C}$ do not show a significant variation along the study period, except for the particularly cold years already mentioned (Fig. 2).

Winter months are also characterised by a lot of freeze-thaw cycles, about 65% of their days per year. Moreover each day is likely characterised by different freeze-thaw cycles, not evaluated because the data set consists only of daily values. For this reason it is not possible to better analyse this parameter in spite of its importance in triggering slope instability (Fig. 3).
In contrast with the parameters analysed above, the absolute minimum temperature shows a positive trend. This behaviour is more evident if we consider that the absolute minimum temperature exceeded –19 °C ten times in the period 1961–2003 and 23 times in the last two decades (Fig. 4).

Also the mean minimums and maximums present a similar trend, but to a slightly lesser extent, with two negative oscillations: the first in the period 1975–1985 while the second started at the beginning of the new century (Fig. 5).

**Summer temperatures.** Besides the analysis of mean, maximum and minimum temperatures, the climatic features of the Summer months were examined concerning the number of tropical days ($T_{\text{max}} < 30$ °C), maximum number of consecutive tropical days, number of days with $T_{\text{max}} = 35$ °C, and the absolute maximum temperatures (Tab. 3).

The mean Summer temperature is 19.9 °C and ranges from 17.6 °C (1976) to 21.3 (1999), the mean values of the minimum and maximum temperatures are 13.5 °C and 26.3 °C
respectively. The number of tropical days, with a mean value of 16.5 days per year, varies between 1 (1978) and 40 (2000). Less frequent are the days with T\textsubscript{max} = 35 °C in fact this value is reached only in about a quarter of the analysed years. The Summer of 1976 is the coolest of the series, this only once the mean summer temperature lowered below 18 °C. Also the summer of 1978 was very cool, the temperature of only one day exceeded 30 °C.

The trend of the summer parameters that we analysed underlines a general increase in temperatures over the last few decades (Fig. 6).

The trend of the number of tropical days shows a remarkable increase since the second half of the 1980s. In fact in the period 1961-1980 the temperature exceeded 30 °C for 210 times, while between 1981 and 2003 this threshold was exceeded 493 times, 247 of which in the last 7 years. Also the trend of days with T\textsubscript{max} = 35 °C shows a similar pattern but it is less marked. The values exceeding 35 °C were recorded for 3 times during the period 1961-1980 and 25 times in the period 1981-2003. Also the absolute maximum temperatures show the same trend (Fig. 7).

Comparing the general trend of the interannual Summer mean temperatures shows an increase that is more evident for the maximum temperatures than for the minimum ones (Fig. 8).

In conclusion, the air temperature analysis highlights a general positive trend, interrupted by a first oscillation during the 70s and another one that started at the beginning of the 21\textsuperscript{st} century, following a period charac-

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Tab. 3. Range of mean Summer temperatures, number of tropical days, maximum number of consecutive tropical days, number of days with \( T\text{max} = 35\degree \) and absolute maximum temperatures

Fig. 6. Interannual trend of number of tropical days (a), maximum number of consecutive tropical days (b), number of days with \( T\text{max} = 35\degree \) (c) at Patărăgele (1961–2003).
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terised by a fast and constant increase in temperatures.(Fig. 9)

Rainfall

The data set available consisted of monthly values of precipitation and extreme pluviometric events for each year (Tab. 4).

The mean annual rainfall is 630.1 mm, ranging from 389.0 (2000) to 857.2 (1969). The rainiest month is June, followed by July and May, while March is the poorest in the least precipitations (Fig. 10).

The general rainfall regime has a main maximum during Summer (40%) followed by Spring (24%). During the study period, six
Fig. 9. Interannual trend of annual mean temperatures at Patârlagele (1961–2003).

Fig. 10. Monthly rainfall regime at Patârlagele (1961–2003).

Fig. 11. Seasonal rainfall regime at Patârlagele (1961–2003).
years had summer rainfalls of more than 50% of the total rainfall of the year while in 1983 this value surpassed 75% (Fig. 11).

The interannual precipitation variability is 2.2, this parameter expresses the ratio between the amount of rainfall in the most humid and most arid year.

The interannual trend of rainfall shows a general negative trend characterised by wide fluctuations. The amount of precipitation shows increases between 1965 and 1975 and again in the first half of the 1990s. It is important to underline that also during the period characterised by a negative trend we can have very rainy years such as 1984, 1988 and 1991 (Fig. 12).

**Extreme rainfall events.** During Summer the study area experiences torrential rainfalls, which have a great impact on the slopes triggering mass movements and causing floods. The maximum daily rainfall for each year of the study period ranges generally between 30 and 70 mm. These low values underline the exceptional nature of the event that occurred on July, 2nd, 1975 when 177.8 mm of rain fell in 24 hours. This value corresponds to 25.5% of the total amount of rain that fell in 1975 (Fig. 13).
In order to calculate the climatic classification and the water balance for the study area, we chose Thornthwaite’s method due to its capacity of representing the water needs of the vegetation, and in order to assess soil susceptibility to erosional processes (Thornthwaite, 1948; Thornthwaite, Mather 1957). Thornthwaite’s method is based on the concept of Potential Evapotranspiration (EP), defined as the amount of water that would be evaporated under an optimal set of conditions, such as an unlimited supply of water (Tab. 5).

The mean annual value of EP is 672.8 mm and varies from 621.9 mm (1976) to 710.9 mm (1994). The mean value of CEET (the ratio summer/annual EP), is 54.3% but some years it exceeds 58% (1987–1988). The interannual trend of EP shows a decrease starting at the beginning of the 1970s with the lowest values recorded in 1976, 1978 and 1980. In contrast, in the last two decades there has been a weak but uniform increase (Fig. 14).

Adopting Thornthwaite’s method, knowing the values of EP and rainfall, it is possible to calculate other parameters such as Deficit (D) and Surplus (S) (Tab. 6).

The annual average of Surplus is 67.8 mm ranging from 0.0, a value recorded in many years, to 225.4 mm (1984). During August and September the Surplus remains close to 0.0, while it reaches the highest values in March and May.
The Deficit, which supplies an estimation of the duration and intensity of the arid period, presents a mean annual value of 122.9 mm and varies from 24.3 mm (1964) to 315.9 mm (2000) (Tab. 7).

The interannual trend of Surplus is negative and this tendency became particularly obvious in the last year of the series, while the general trend of Deficit shows wide oscillations (Fig. 15).

**Soil moisture budget.** The amount of water held in the soil depends on the rainfall and EP, while the amount of water that the soil can hold depends on the characteristics of the ground, such as texture and quantity of organic substances contained. This parameter is known as field capacity and its value is 150 mm in the Muscel valley. During an average year the field capacity is never reached while during the study period this value is reached and even exceeded in almost all the months (Tab. 8). When the soil is saturated the Surplus becomes an underground, hypodermic and superficial flow.
Climatic formula. Some important indices can be calculated combining EP, S and D. In particular the relation $I_m = \frac{(S-D)}{EP}$ results into the index of global moisture ($I_m$), which is the most important index in the climatic classification suggested by Thornthwaite (Fig. 16).

The mean value of $I_m$ for the study period is -3.6 and this corresponds to the subarid type $C_1$. The minimum value recorded in this period was −4.2 (2000) and corresponds to type D (semiarid), while the maximum is 31 and represents the humid type ($B_1$) (Tab. 9).

Using the analysed values it is possible to obtain a climatic formula composed of four letters. The first indicates the $I_m$, the second represents the EP, the third is the Index of aridity or humidity and the last is the value of CEET. This formula indicates the climatic features of the study area, taking into consideration latitude, temperatures, precipitation and soil field capacity (Tab. 10).

Conclusions
The analysis of the thermopluviometric data recorded at Pätârlagele station in the period 1961–2003 enables us to define the general climatic characteristics of the study area and, at the same time, to identify the rainiest period and the extreme rainfall events.

The mean yearly temperature is 10.4 °C ranging from 8.9 °C (1976) to 11.7 °C (1989-1994). The general trend shows an increase since the end of the 1970s, consisting in greater increase of Summer temperature as
Climatic features of the Muscel Valley (Buzău Subcarpathians, Romania) compared to those of Winters; the pattern is quite regular even if sometimes it is interrupted by some cold years. In particular since 2000, a rapid decrease of temperatures has occurred which is much more evident in 2003, when it was very hot in many European countries. This anomalous heat wave did not affect Romania probably because the Azores Anticyclone, responsible for this event together with the North-African anticyclone, only slightly influences this area.

Regarding rainfall, the mean yearly precipitation is 630.1 mm, ranging from 389 mm (2000) to 857.2 mm (1969), with the main maximum in Summer. This season is affected by extreme rainfall events, the most well-known is that of July 2nd 1975, which caused widespread floods and many mass movements in the valley. The general trend is negative, especially in the few last years.

The climate of the Muscel valley is classified as subarid, first mesothermic, characterised by a small excess of water and with a CEET of 54.3%. In the last years a tendency to dryness has been recorded due to the increase in temperatures and decrease in rainfall, giving semiarid features to the climate.

BIBLIOGRAPHY


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